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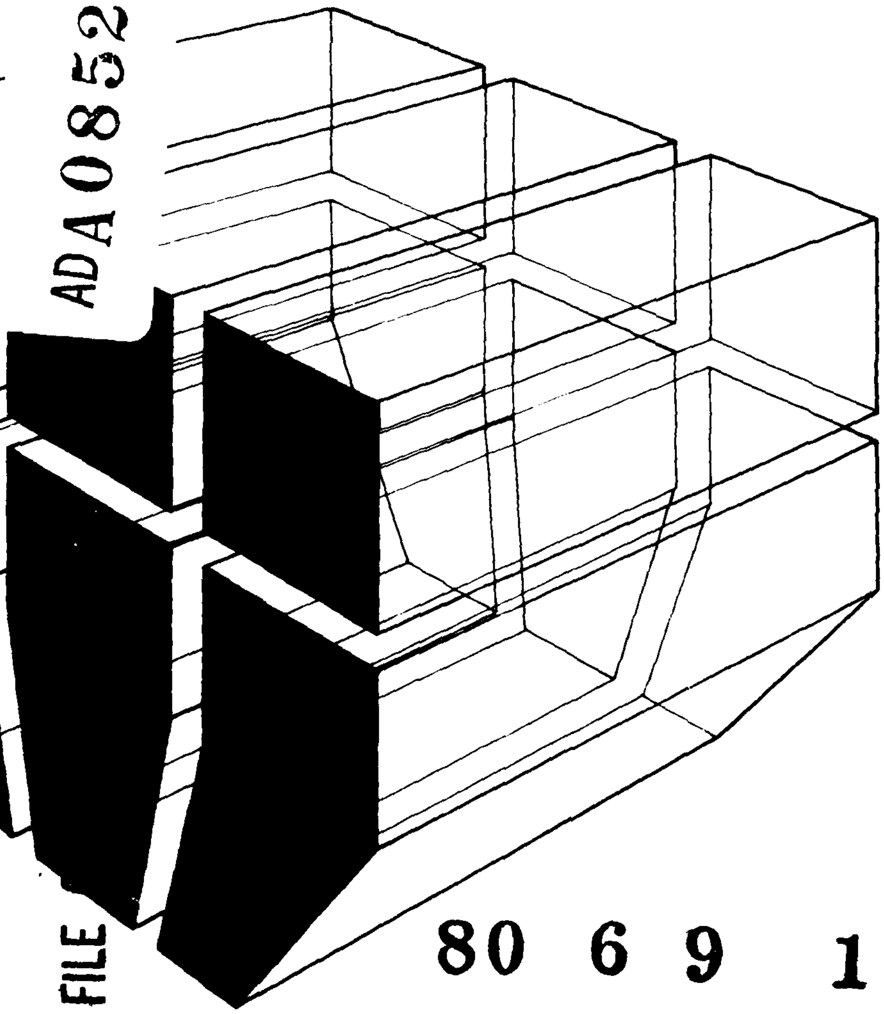
May 1980
Methods to Reduce Electrical Consumption

AN ANALYSIS OF ELECTRICAL CONSUMPTION AT REPRESENTATIVE ARMY INSTALLATIONS

by
L. M. Windingland



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ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes an analysis of monthly and daily electrical energy consumption data collected over 2 years from 8 electrical feeders at Fort Carson, CO, and 20 different Army buildings at Fort Carson and at Fort Belvoir, VA. The work was conducted to determine why electrical energy consumption has been increasing at Army installations, and to provide a basis for determining methods to reduce consumption. → next page

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It was determined that many Army buildings have a high minimum electrical usage (minimum demand) that amounts to up to 75 percent of total annual consumption. Tables and graphs are provided which amplify the significance of this minimum demand. It was concluded that a shift from emphasizing a reduction in occupant usage of electrical energy to a concentrated effort to minimize the continuous electrical usage caused by building operation and heating, ventilating, and air-conditioning (HVAC) systems should reduce electrical consumption at Army installations.

FOREWORD

This work was performed for the Directorate of Military Programs, Office of the Chief of Engineers (OCE), under Project 4A762731AT41, "Design, Construction and Operation and Maintenance Technology for Military Facilities," Technical Area G, Work Unit 004, "Methods to Reduce Electrical Consumption." Mr. Homer Musselman, DAEN-MPO-U, was the OCE Technical Monitor.

The work was performed by the Energy Systems Division (ES), U.S. Army Construction Engineering Research Laboratory (CERL). Mr. R. G. Donaghy is Chief of ES. Appreciation for his support during building field surveys is expressed to Hank Gianilliat, U.S. Army Facilities Engineering Support Agency, Technical Support Division.

COL Louis J. Circeo is Commander and Director of CERL and Dr. L. R. Shaffer is Technical Director.

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AN ANALYSIS OF ELECTRICAL CONSUMPTION AT REPRESENTATIVE ARMY INSTALLATIONS

1 INTRODUCTION

Background

The Facilities Engineering Annual Summary of Operations (FY75 through FY78) indicated that Army installations world-wide spent $275 million for electrical energy in FY78.[1] Of this amount, $173 million was spent in the continental United States. This electrical energy expenditure is of great concern to installation commanders and Major Commands (MACOMs). The Army must reduce the consumption of electrical energy in its buildings, both to minimize total dollar expenditures and to comply with the Presidential Executive Order to reduce average energy use in existing buildings by 20 percent by the year 1985 (based on consumption levels established during FY75). However, several Army MACOMs have increased electrical energy use since the FY75 baseline was established. Although the Army has had substantial success in reducing its thermal energy requirements, efforts to reduce electrical energy consumption have been less than satisfactory and additional emphasis on electrical conservation appears necessary. Records for FY78 show that the use of electricity at Army installations has increased by 6.6 percent since FY75; since FY75, the cost of electricity has increased 56 percent. Therefore, electrical energy consumption remains a significant Army expenditure in terms of both dollars and energy.

Although Facilities Engineers and MACOMs have placed considerable emphasis on reducing electrical energy consumption, they have yet to realize major savings. Therefore, the U.S. Army Construction Engineering Research Laboratory (CERL) was asked to help Facilities Engineers determine why electrical energy consumption is increasing and to develop methods of reducing electrical consumption on Army installations.

Objective

The overall objective of this study is to (1) describe how electrical energy is being used on military installations, (2) describe the major causes for changes in electrical energy usage, and (3) suggest operational changes and equipment techniques that will reduce electrical energy consumption which Facilities Engineers can use to plan and execute effective electrical conservation programs.

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[1] Facilities Engineering, Annual Summary of Operations, Fiscal Years 1976 through 1978 (Department of the Army, Office of the Chief of Engineers, 1979).

The objective of this report is to document (1) and (2) above (Phase One of the overall research effort).

Approach

Phase One of this study consisted of the following steps:

1. Representative Army installations were selected for electrical energy consumption analysis. Data from these analyses were used to draw general conclusions about similar operations and problems Army-wide.

2. General information on installation consumption was obtained.

3. Installation electrical energy consumption by feeder area was analyzed.

4. End-use electrical energy consumption was determined by performing short-term onsite measurements of lighting, equipment, air conditioning, and other individual electrical consumers.

5. Installation procedures and techniques currently used to reduce electrical energy consumption were observed and evaluated.

6. The effects of occupant activities and the lifestyle of building users on electrical energy consumption were determined.

7. A method for Facilities Engineers to use in performing building inspections to eliminate electrical energy waste was developed.

8. How electrical energy is being used on the selected installations was described and probable causes for increases or decreases in annual consumption were determined.

Phase Two of this study will:

1. Evaluate selected installations to determine their potential for electrical energy reduction.

2. Prepare recommendations for retrofit opportunities or probable operational changes that would be necessary to reduce electrical energy consumption.

3. Investigate electrical power demands and the power cost/billing structure to determine if there is potential for savings with peak electrical demand saving techniques or power factor correction.

4. Describe how electrical energy is being used, determine the impact of demand charges, identify major causes of electrical energy use increases or decreases, evaluate the potential for electrical energy reduction, suggest methods for achieving this reduction, and analyze the impact that these recommendations will have on Army installations.

Mode of Technology Transfer

The information gathered during Phases One and Two of this study will be used to prepare an Engineer Technical Note describing recommended methods and procedures for reducing electrical energy consumption on Army installations.

2 DATA COLLECTION PROCEDURES

Selection of Installations for Study

The installations selected for this electrical consumption study were primarily those that had electrical energy-use data detailed enough to be analyzed. Most installations have little more than a master meter at the substation entering the installation. However, in 1975, an Army metering project was set up to monitor more than 100 Army installation buildings for electrical and thermal energy demands; several installation feeders were also monitored.[2] These data, gathered on an hourly basis, are generally available for a 2-year period beginning in FY77. The two installations selected for analysis in this study are participants in that energy monitoring project: Fort Belvoir, VA, a TRADOC installation; and Fort Carson, CO, a FORSCOM installation. Both of these installations, according to the Facilities Engineering Annual Summary of Operations Report (FY75 through FY78), showed an increase in electrical energy use from the period FY75 to FY78.

Electrical Feeder Energy-Use Data

Most installations purchase their electrical energy from local communities; it is normally fed at a high voltage to a single substation and distributed from that substation on feeders to various sections of the installation. The feeders analyzed as part of this study are part of the Fort Carson distribution system, which consists of two main substations that step down the 34.5 kV incoming service for distribution throughout the installation. (Service is supplied by the City of Colorado Springs, CO.) Figure 1 is a one-line diagram showing the electrical distribution system at Fort Carson.

Under the energy monitoring project, the eight feeders being served by Substation No. 1 are being monitored. Energy-use data from meters installed on the individual feeder lines served by Substation No. 1 were analyzed during this study to identify seasonal, extremely high or low consumption, or load shifting -- if any -- in electrical energy usage. If any particular areas of the installation exhibited such trends, a further analysis was then performed and a breakout made of the electrical energy usage by building or by building function (i.e., lighting,

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[2] B. Sliwinski, D. Leverenz, and L. M. Windingland, Fixed Facilities Energy Consumption Investigation -- Data Analysis, Interim Report E-143/ADA066513 (U.S. Army Construction Engineering Research Laboratory [CERL], February 1979); L. M. Windingland, R. J. Sliwinski, Fixed Facilities Energy Consumption Investigation -- Initial Energy Data, Interim Report E-120 (CERL, January 1978); and L. Windingland, B. Sliwinski, and A. Mech, Fixed Facilities Energy Consumption Data User's Manual, Interim Report E-127/ADA051678 (CERL, February 1978).

air conditioning [AC] equipment); particular building types predominant within the feeder area would also be analyzed (by surveys and metering) to determine their contribution to the total feeder consumption.

Building Electrical Energy-Use Data

Twenty buildings were selected for analysis. The buildings were selected based on their repetitive construction (numerous similar buildings on the installation) and on the availability of complete actual electrical consumption data for a 2-year period. These buildings, their function and location are listed in Table 1. The total consumption by month for 2 fiscal years was determined from energy-monitoring project data. A determination of the AC load on the building, the base load on the building, building peak and minimum demands, seasonal changes in energy usage, and evidence of increases or decreases in electrical energy consumption for the building were identified. Energy-use data were extracted both on an hourly basis (for daily analysis), and on a monthly basis (for total consumption).

Electrical Energy Conservation Programs

Army installations are required to have energy conservation programs. The installations studied had prepared a supplement to Army Regulation AR 11-27 to cover the majority of energy conservation actions.[3] All actions that the installations had taken to encourage electrical energy conservation were noted, and observations were made to determine their effectiveness.

Installation Observations and Onsite Measurements

Each of the selected installations was visited to determine the effectiveness of its electrical energy conservation program. Discrepancies between items within each installation's energy conservation program and operational or occupant usage of facilities were noted. Short-term, onsite measurements were made at several facilities to determine actual AC consumption, lighting consumption, and other equipment consumption.

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[3] Army Energy Program, Army Regulation (AR) 11-27 (Department of the Army, 20 July 1976).

3 DATA ANALYSES AND FINDINGS

Feeder Data Analyses

Tables 2 and 3 show the July 1976 through June 1978 electrical consumption for the eight monitored feeders at Fort Carson, CO. It can be seen that fairly wide fluctuations in usage occur between individual feeders, and on a month-to-month basis for any particular feeder. The tables show that there are no clear and consistent seasonal trends or evidence of consistent increases or decreases in consumption by individual feeder. It appears from the tables that loads are switched from one feeder to another, which would explain some of the major differences in monthly consumption (e.g., Table 3 shows more than a 1-million kWh difference for the month of November between Feeders 3 and 4). It was expected that major consumers on the installation could be determined by observing these data. With that information, reasons why and how electric energy was being used would be better defined. However, the inconsistency, nonevidence of trends, and missing data caused the analyses of monthly feeder consumption data to be inconclusive.

An analysis of daily consumption for the feeders produced more interesting results. Table 4 shows the daily consumption, peak hourly consumption, minimum hourly consumption, and minimum percent of daily total for the feeders at Fort Carson. Included in the table are values for winter and summer days, for both a weekend and a weekday. Note that the minimum demand consumption (extended over 24 hours) is a significant portion of the total consumption. For example, Feeder 1 on Sunday, 11 June 1978, consumed 20,950 kWh, had a maximum hourly consumption of 1002 kW, and a minimum hourly consumption of 672 kW. When this minimum demand is multiplied by 24 hours, the result is 16,128 kWh -- 77 percent of the total daily consumption. This value, which might be termed a "minimum baseline consumption," varies from 54 percent to 91 percent and averages 71 percent for the data listed in Table 4. The weekend (Sunday) baseline averages 75 percent; the weekday (Tuesday) baseline, as might be expected, is lower (68 percent). These values, which are different for each feeder and probably change slightly every day, indicate that the installation consumes approximately 70 percent of its electrical energy during minimum operational status. The data conversely indicate that approximately 30 percent of electrical energy is consumed by operational functions. Figure 2 shows the winter monthly profile for one of the feeders at Fort Carson. The hourly demand of electricity being used along this feeder is shown for 1 to 25 January 1978. The total consumption for this period is 447,300 kWh; the minimum hourly demand is 470 kW, and the maximum hourly demand is 1360 kW. The minimum percentage of total consumption is 63 percent. This value is obtained by multiplying the minimum demand (470 kW) by the number of hours of monitoring and dividing by the total consumption. In this case, 470 kW x 24 hours/day x 25 days ÷ 447,300 kWh = 0.63. This means the area under the curve bounded by the minimum demand consists of 63 percent (282,000 kWh) of the total area (447,300 kWh) under the curve.

Minimum demand consumption can also be expressed as continuous demand on the feeder. The feeder shown in Figure 2 serves 85 installation buildings through 56 transformer banks of 3280 kVA total capacity. Figure 3 shows the buildings and systems served by Feeder 2. Figure 4 shows the profile for a summer month -- 6 to 30 June 1978. This profile shows a 54 percent minimum consumption. Figures 3 and 4 indicate that substantial electrical energy is being consumed by the high minimum baseline demand. Table 5 shows the weather conditions at Fort Carson for the days listed in Table 4, including heating degree days (HDD) and cooling degree days (CDD). For the four days listed in Table 4, the installation minimum demand occurs between 2 and 4 AM; the maximum demand consistently occurs at 2 PM.

Building Data Analyses

Twenty buildings were analyzed for their annual and daily electrical consumption. The monthly electrical consumption data, weekday and weekend daily consumption, hourly maximum demand, hourly minimum demands, and physical data for these buildings are shown in Tables 8 through 27. Each building will be discussed separately.

Table 6 shows the weather parameters at Fort Carson and Fort Belvoir for the days daily data were reported. Included in Table 6 are daily maximum and minimum temperatures, daily average temperatures, and HDD or CDD as reported by the National Oceanic Atmospheric Administration (NOAA), National Climatic Center, Ashville, NC. Table 7 shows the corresponding HDD and CDD associated with the monthly consumption data.

Table 8 shows data from Building 1430, an administration building at Fort Carson. This building consumes, on the average, 0.0315 kWh/sq ft/day. The monthly consumption data in Table 8 show no significant differences between 1976 to 1977 and 1977 to 1978 data. Note that the building exhibits a fairly large minimum base demand -- about 32 kW (768 kWh daily); i.e., 58 percent of the energy consumed in the building is not directly related to occupancy. The difference between the minimum and maximum hourly demands for weekdays can be largely attributed to lighting and equipment, particularly telecommunications equipment. This shows up clearly in the connected equipment kW load listed in Table 8.

Cooling season consumption for Building 1430 is slightly higher than heating season consumption. The maximum hourly weekday consumption in the summer is 100 kW and the maximum winter weekday demand is 90 kW. The monthly consumption data also show that summer consumption is about 3000 kWh/month higher than winter consumption.

Figure 5 is a plot of the electrical energy consumption for 7 to 27 January 1978. Values corresponding to minimum, maximum, and total consumption are included for clarity. Figure 5 compares minimum demand and daily usage to total consumption. Figure 6 shows a similar plot for summer energy consumption for 7 to 21 July 1978.

Table 9 shows data for Building 7300, the officer's open mess facility at Fort Carson. This building consumes, on the average, 0.070 kWh/sq ft/day. Cooling season consumption for Building 7300 shown in the monthly consumption data in Table 9 is higher than heating season consumption. The difference between summer consumption and winter consumption is about 20,000 kWh/month. The minimum hourly demand during unoccupied periods is 55 percent of the daily total consumption. Much of this minimum demand can be attributed to the refrigeration equipment and the heating, ventilating, and air-conditioning (HVAC) system used within the facility. (Further study, including onsite visits and equipment monitoring, would be necessary to define the exact cause of the minimum load during unoccupied periods.) The monthly consumption data also show that this facility has reduced its energy consumption by roughly 10 percent from 1977 to 1978. Note that the AC load is a substantial portion of the summer energy consumption, as indicated by the AC equipment connected load of 48 kW listed in Table 9.

Table 10 shows data for Building 1525, the commissary at Fort Carson. This building consumes, on the average, 0.09 kWh/sq ft/day. The monthly electrical consumption data in Table 10 show that summer consumption is substantially higher than winter consumption because of the large amount of AC equipment (138 kW connected load) installed in the building. The seasonal consumption data show that the building consumes about 65 percent of its energy on a continuous basis. Note that on Sundays (when the building does not have customers) there is still substantial daily electrical consumption (5620 kWh in the winter and 7010 kWh in the summer). This is primarily caused by the building's refrigeration loads.

Table 11 shows data for Building 7304, a bachelor officer's quarters at Fort Carson. Building 7304 consumes, on the average, 0.0137 kWh/sq ft/day. The monthly consumption data in Table 11 show that this building's electrical energy use increased during the winter months. Since the building is not cooled, this increase can be attributed to heating system pumps and fans and additional lighting required by shorter daylight hours. The building did not show any substantial increase or decrease in consumption between 1977 and 1978. Although this building does not have a profile similar to operational-type buildings, the hourly minimum most often occurs in the early morning. However, the minimum usage -- predominantly heating and cooling equipment -- is a substantial (60 percent) portion of the total daily consumption.

Table 12 shows data for Building 1953, a bachelor enlisted quarters at Fort Carson. Building 1953 consumes, on the average, 0.0179 kWh/sq ft/day. It is served from a central plant which supplies both hot and chilled water to the HVAC system. The data show a slight increase in electrical energy consumption during the winter months. This increase can be attributed to fewer daylight hours, i.e., a need for more lighting, and higher use of heating system fans than in the cooling season. The minimum demand (12 kW) over a 24-hour summer period was 70 percent of the daily total usage. Figure 7 shows the consumption profile for 1

to 25 January 1978. This profile is considerably different from Building 1430, the administration building; Building 1953's profile has less pronounced peaks and smaller variations between weekends and weekdays.

Table 13 shows data for Building 811, a bachelor enlisted quarters with dining facilities at Fort Carson. Building 811 consumes, on the average, 0.015 kWh/sq ft/day. The monthly consumption data in Table 13 show a slight decrease in electrical energy use from 1977 to 1978. These data also show that there is no consistent seasonal variation in monthly electrical energy consumption. This building also has a substantial minimum hourly demand (66 percent of the daily total). The difference between the minimum hourly demand and the maximum hourly demand can be attributed to food preparation in the dining portion of the building, occupant lighting, and laundry.

Table 14 shows data for Building 1219, a bachelor enlisted quarters at Fort Carson. Building 1219 consumes, on the average, 0.0093 kWh/sq ft/day. The monthly consumption data in Table 14 do not show any major variation between summer and winter consumption. The minimum demand constitutes 60 percent of the annual consumption. A 1 kW reduction in the minimum demand (8760 kWh/year) would create a 5 percent reduction in annual consumption for Building 1219.

Table 15 shows data for Building 1044, a bachelor enlisted quarters at Fort Carson. Building 1044 consumes, on the annual average, 0.012 kWh/sq ft/day. The monthly consumption data in Table 15 show that a significant decrease in electrical energy consumption occurred between 1976 to 1977 and 1977 to 1978 data. (The reason for this decrease has not been determined.) Building 1044's seasonal consumption data show that cooling season consumption is considerably higher than heating season consumption. This increase can be attributed to the operating hours of the fans used for cooling; the building is heated by fin tube radiation around the building's inside perimeter.

Table 16 shows data for Building 1230, a recreation center at Fort Carson. Building 1230 consumes, on the average, 0.014 kWh/sq ft/day. The monthly consumption data in Table 16 show no significant variations from 1977 to 1978. Summer consumption is considerably higher than winter consumption, mainly caused by no cooling equipment. This building consumes roughly 67 percent of its energy during the nonoperational mode. Therefore, the amount of consumption which can be attributed to building occupants is 33 percent of the total annual consumption.

Tables 17 and 18 show data for Buildings 2492 and 2992, identical maintenance facilities at Fort Carson. Buildings 2492 and 2992 have an annual average consumption of 0.032 and 0.028 kWh/sq ft/day, respectively. Although these two facilities are identical in function, size, and equipment, Building 2992 consumes roughly 20 percent less electrical energy than Building 2492. The major reason for this difference is the minimum hourly consumption of the two facilities. Building 2492 has a weekday minimum of about 20 kW in the summer and 40 kW in the winter;

Building 2992 has a 6 kW minimum in the summer and a 30 kW minimum in the winter. There is no electrical usage in the building that pertains directly to the maintenance function, i.e., no battery chargers, welders, or electric tools are being used to maintain equipment. Electrical energy used in these buildings is for lighting, heating and ventilation, overhead doors, and electric windows. The major reason for differences in their electrical usage appears to be in the operation of the heating and ventilating systems. Each building has exhaust fans which remove air from the ground floor of the building and vent to the exterior. In addition, numerous unit heaters located about 12 ft (3.6 m) above the floor are connected to individual thermostats. Ten thermostats were visually observed and eight were found set at a temperature of 90°F (17.8°C). Unit heaters were operating when the outside air temperature was 60°F (15.6°C) and the overhead doors to the maintenance bays were fully open.

Figures 8 and 9 show plots of winter electrical usage for Buildings 2492 and 2992, respectively. These curves show the high minimum consumption of Building 2492 and the higher maximums attributed to operational usage in Building 2992. Figure 8 shows the high minimum consumption (75 percent of total consumption for Building 2492) and the variation (36 to 71 kW) between minimum and maximum hourly demands. Figure 9 shows Building 2992's much lower (30 percent) minimum consumption and much larger variation (6 to 66 kW) caused by its operations and occupancy.

Figures 10 and 11, the summer monthly profiles for the two buildings, show a sharp drop in minimum demand. Building 2492's minimum demand went from 36 to 10 kW, and Building 2992's minimum demand went from 8 to 2 kW. Note that the decrease in minimum demand directly relates to the total consumption, which is also much lower during the summer months.

Table 19 shows data for Building 216, an administration building at Fort Belvoir. Although there are few data available for Building 216, indications are that it consumes, on the average, 0.0146 kWh/sq ft/day. This building shows a very small minimum hourly demand for summer months, and only a slight increase in demand in the winter months -- about 8 kW/hour/day. It appears that this building's minimum hourly demand is well within consumption ranges; the daily consumption profile shows that Building 216 follows the profile expected of an administrative building. The low minimum demand is caused by the type of heating system installed in the building; this system uses hot water radiation instead of forced air and, therefore, has a small electrical demand.

Table 20 shows data for Building 20, the officer's open mess facility at Fort Belvoir. Building 20 consumes, on the average, 0.051 kWh/sq ft/day. The monthly consumption data in Table 20 show substantial increases for the summer months (when AC is used). The data do not show any substantial, consistent trend in increases or decreases from 1976 to 1977 or 1977 to 1978. Building 20's minimum hourly demand in both

summer and winter is very high, i.e., 75 percent of the annual total consumption. This building is cooled by two 100-ton individual compressors, which causes summer electrical energy consumption to be substantially higher than winter consumption. This high summer demand is also reflected in the daily summer and daily winter seasonal consumption data.

Table 21 shows data for Building 1099, a dental clinic at Fort Belvoir. Building 1099 consumes about 0.044 kWh/sq ft/day. The monthly consumption data in Table 21 show that Building 1099 uses almost twice as much electrical energy during the summer cooling months as it uses during the winter heating months. This increase is also reflected in the seasonal consumption data, which show a difference in maximum weekday hourly demands between summer and winter operations of 50 percent. In this building, the AC system was left running on Saturdays and Sundays. The difference between the hourly minimum for summer weekends and weekdays is caused by the building user shutting down the AC during the night on weekdays, but failing to shutdown the AC on weekends; i.e., the weekday minimum is only half that of the weekend minimum. This building would be a candidate for clock-controlled HVAC.

Table 22 shows data from Building 2120, a theater at Fort Belvoir. Building 2120 consumes an average of 0.0296 kWh/sq ft/day. The monthly consumption data in Table 22 show considerable fluctuation between summer and winter consumption and from month to month, with no evidence of increases or decreases from one year to the next. The seasonal consumption data show a very reasonable minimum consumption for the summer considering a minimum operational status which includes security lighting, fire alarm, clocks, and safety lighting. However, the winter minimum consumption is 80 percent of the total daily consumption. The effects of occupancy within the building (i.e., lighting, projectors, and concessions), therefore, contribute only 20 percent to the total daily consumption during the winter months.

Table 23 shows data for Building 508, a bachelor officer's quarters at Fort Belvoir. Building 508 consumes, on the average, 0.0128 kWh/sq ft/day. This building consumes roughly twice as much electrical energy in the summer as it does in the winter. The data show that the AC is turned on about mid-June and off in mid-September. The summer minimum demand is about 70 percent of the daily total and the winter minimum demand is 58 percent of the daily total. Weekend consumption is slightly higher than the weekday consumption.

Table 24 shows data for Building 2111, a bachelor enlisted quarters at Fort Belvoir. Building 2111 consumes, on the average, 0.0135 kWh/sq ft/day. The monthly consumption data in Table 24 show an increase in electrical energy use during the winter months. This increase can be attributed to longer operation of fan coil units and extended hours of lighting during the winter. Since this building is cooled by chilled water from a central plant, no electrical cooling energy is being used besides the fan and pump energy. The building did not show any

substantial increases in electrical energy consumption between 1977 and 1978. Note that this building's winter and summer minimum hourly demand is equal -- 8 kW. This minimum demand, if extended for the entire year (8 x 24 x 365), would produce a total of 70,000 kWh vs an actual consumption of 95,000 kWh. The minimum demand is, therefore, 73 percent of the total annual consumption.

Table 25 shows data from Building 203, a bachelor enlisted quarters at Fort Belvoir. Building 203 consumes, on the average, 0.0107 kWh/sq ft/day. The monthly consumption data in Table 25 show that the highest electrical consumption occurs during the cooling months of July, August, and September, more than twice the consumption shown during the heating season. The hourly minimum of this building is 7 kW (cooling or heating), or 64 percent of Building 203's annual electrical energy consumption.

Table 26 shows data for Building 1200, an enlisted dining facility at Fort Belvoir. Building 1200 consumes, on the average, 0.026 kWh/sq ft/day. The monthly consumption data in Table 26 show a fairly consistent consumption of electrical energy throughout the summer and winter periods, even though the building has a 100-ton AC unit. The seasonal consumption data show that the weekend daily consumption is about 15 percent higher than the weekday consumption, and that the minimum hourly consumption of 20 kW is consistent both in the summer and the winter. If the 20 kW minimum hourly consumption is extended for 24 hours and 365 days a year, the minimum consumption in Building 1200 can be computed to be 72 percent of the total annual consumption.

Table 27 shows data for Building 1949, a motor pool at Fort Belvoir. Building 1949 consumes, on the average, 0.0125 kWh/sq ft/day. Since this building has no cooling, the monthly electrical energy consumption in the winter is higher than in the summer. Of interest is the winter minimum demand -- 5 kW for weekends (nonoperational) and only 3 kW for weekdays. There is no apparent reason for this, but it is suspected that the heating system is being manually controlled during the week, but not on weekends. The minimum demand for summer is extremely small -- 0.2 kW, which can be attributed to the water heater and security lighting.

Summary

A major portion of the electrical energy consumption of the buildings analyzed during this study occurs during nonduty or unoccupied hours. In many instances, annual unoccupied consumption contributes up to 75 percent of the total annual consumption of the facility. It appears from these data, then, that substantial emphasis should be placed on reducing minimum baseline electrical energy consumption. A reduction of this minimum bascline would provide savings every hour of the year, and should provide a corresponding reduction in peak maximum demands.

4 OPERATIONAL FINDINGS

Fort Belvoir

Electrical energy conservation at Fort Belvoir is a part of the Utility Energies Conservation program, which is under the Directorate of Facilities Engineering. Fort Belvoir's overall energy conservation program is supervised by the Directorate of Industrial Operations (DIO). The Energy Conservation Council (ECC) implements and coordinates this energy conservation program. ECC membership includes the DIO; the Director of Facilities Engineering; the U.S. Army Engineer School; the Division of Personnel and Community Facilities; Unit Commanders; and Tenant Activities. Unit/activity energy conservation officers are appointed for specific buildings and areas. Periodic surveys are conducted to identify potential conservation actions such as reducing the number of lights in hallways, supply rooms, warehouses, dining facilities, and to make sure equipment is turned off when not in use. Possible consolidation of functions to reduce the number of buildings being used is also considered.

The program to reduce electrical energy consumption at Fort Belvoir includes:

1. Reducing outdoor lighting not required for mission safety or security.

2. Reducing lighting at work stations, work areas, and nonworking areas to recommended footcandle levels.

3. Limiting or delaying the turn-on of AC systems, except for facilities such as medical, data processing, or laboratory buildings.

4. Changing working hours to permit early AC turn-off during peak cooling months.

5. Setting AC controls to a maximum cooling temperature of between 78 and 80°F (25.5 to 26.6°C).

6. Publishing electrical energy saving practices, tips, and encouraging participation in an energy conservation suggestion program.

7. Scheduling athletic events for daylight hours.

Fort Belvoir has activated two facilities over the past 3 years, including a flight-simulation building and a night-vision laboratory building. Other recent building modifications include installation of an AC system in the Defense Systems Management College and in the installation library. There have been no major deactivation of facilities in the past 3 years. Fort Belvoir's troop and civilian personnel population has decreased slightly since 1977.

There are currently four active energy conservation projects at Fort Belvoir:

1. A building delamping project to reduce lighting to recommended footcandle levels.

2. A project to replace street lighting to reduce the lighting levels from 2500 lumens to 1000 lumens.

3. A project to change street lighting in family housing areas from incandescent lamps to high-pressure sodium lamps.

4. A load shedding project which includes the use of timeclocks to reduce AC loads during the cooling season.

An installation-wide energy study to examine electrical energy use is also in progress. It is a phased study which will identify quick-fix conservation measures. The study is being conducted by a contractor under the supervision of the Baltimore District of the U.S. Army Corps of Engineers.

Table 28 shows the electrical energy consumption (by month) for FY77 to FY79 at Fort Belvoir. Major electrical consumers on the installation include the hospital, the research and development area (MERADCOM), the Kingman Complex (Buildings 2992 and 2993), and family housing.

Fort Carson

Electrical energy conservation activities at Fort Carson are integrated into the installation's overall energy conservation program. An energy conservation office under the Deputy Installation Commander has staff responsibility for the program. An energy conservation board implements and coordinates energy conservation measures. Board membership includes: the DIO, the Directorate of Facilities Engineering, the Director of Personnel and Community Activities, and Unit Commanders. The board members appoint unit activity conservation officers who are responsible for assigned buildings and areas. They perform periodic surveys and inspections of their areas to identify measures for reducing consumption such as storage consolidation or lighting level reduction.

The program to reduce electrical energy consumption at Fort Carson includes:

1. Reducing the use of lights in offices and billets by performing lighting surveys to measure footcandle output.

2. Establishing a new schedule for turning exterior lights on and off to assure optimum use of daylight.

3. Limiting or delaying turn-on of AC systems, except for medical, data processing, and other areas requiring a controlled environment.

4. Setting AC controls at 78 to 80°F (25.5 to 26.6°C).

5. Publishing energy conserving suggestions to encourage installation-wide participation in the program.

6. Limiting the use of outdoor or decorative lighting except where safety or security is involved.

7. Scheduling athletic events for daylight hours.

New facilities activated at Fort Carson since 1977 include a dental clinic, a headquarters building, and several modular barracks buildings. No major facilities have been deactivated, but a continuing program to phase out old temporary buildings (e.g., barracks) as new facilities are completed is in effect. There has been no major change in the resident or nonresident population at Fort Carson since 1977.

There are currently three active electrical energy conservation projects at Fort Carson:

1. A delamping project for shops and offices (this project is continuing and is monitored through periodic building inspections).

2. A project to replace mercury vapor street and parking lot lights with high-pressure sodium lamps.

3. A project to correct power factors by installing capacitors and encouraging load shedding. Also, as a part of the installation energy conservation efforts, a baseline energy study is being conducted by a contractor under the supervision of the Omaha District of the U.S. Army Corps of Engineers. This study is expected to be completed in FY80. Table 29 shows the electrical energy consumption (by month) at Fort Carson from FY77 to FY79.

Discussion

Both Fort Belvoir and Fort Carson have established energy conservation programs that included electrical considerations in their development. The programs are similar and both have placed primary emphasis on reducing occupancy-related energy consumption. Both programs have implemented projects to reduce consumption, but it will not be possible to do a precise, quantitative evaluation of project results until they are completed and until there is widespread metering of buildings included in the programs. However, results to date from data gathered from buildings on both installations which were metered under the energy monitoring program do not indicate any across-the-board reductions which can be attributed to installation energy conservation efforts.

In addition, the total installation consumption data do not show reduction in electrical usage over a 3-year period (Tables 28 and 29).

General Trends Indicated by Representative Installation Analyses

Although Army installation energy conservation officers and Facility Engineering personnel feel confident that their energy conservation plans were working, many discrepancies within buildings and electrical energy waste were observed during visits conducted for this study. Some specific examples of such waste are:

1. Lights left on when lighting was not required (this included classrooms, mechanical rooms, hallways, and exterior lights burning during daytime hours).

2. Malfunctioning HVAC equipment; e.g., a compressor left on when there was no AC load, faulty dampers stuck in the open or closed position, fully opened outside air dampers when the temperature outside was very warm, dirty filters, fans operating in areas not being used and when the building was unoccupied, and many timeclocks that were installed but subsequently disconnected.

3. Exceptions to the AC turn-on policy for facilities such as officer's clubs, noncommissioned officer's clubs, hospitals, and dental facilities, practically all nonappropriated funds (NAF) activities, and many housing units. In addition, building temperatures during the cooling season were often lower than the required 78 to 80°F (25.5 to 26.6°C).

Onsite measurements were made at representative Army facilities by using recording ammeters for periods from 2 to 36 hours. Many of the discrepancies mentioned above were discovered during these measurements. For example, a recording ammeter was left on two AC units for 24 hours. One AC unit showed a continuous demand of 140 A -- at no time during the 24 hours did this particular unit turn off or cycle. A second AC unit in the same building cycled repeatedly during the 24 hours it was monitored. It was concluded that the first AC unit's controls were malfunctioning, since it was always operating in an unloaded condition and was not contributing to the AC load of the building. Another building (an enlisted dining facility) was continuously monitored to determine its AC consumption. It was found that its AC system operated continuously, even during periods when the building was unoccupied.

Summary

A large percentage of the total annual electricity consumption of buildings at Army installations seems to be caused by the magnitude of the minimum baseline consumption (lowest hourly demand/consumption). This minimum amount is being consumed for every hour of the year. A 1 kW reduction in the minimum demand in a building would save 8760 kWh/year, which would be equal to a 5 percent reduction in Army buildings such as those described in Tables 11 through 16. Therefore, substantial savings in electrical energy consumption can be achieved by reducing a building's minimum demand.

The present emphasis and control of electrical conservation policy and methods at Army installations requires additional attention. The minimum demand on an installation is caused by a variety of items including street and security lighting, housing, entertainment, and heating and cooling equipment. The minimum demand in many of the buildings can be attributed mainly to the heating and cooling system operation (fans, pumps, compressors) and is not directly related to occupancy requirements.

To date, the emphasis in Army installation energy conservation efforts has been primarily aimed at building occupants. However, data indicate that most of a building's electrical energy use is not directly related to building occupancy. Therefore, energy conservation programs which emphasize reducing building operational demands should be developed.

To help Facilities Engineers determine where the electricity is being used in buildings and to help develop a method to reduce this consumption, an inspection procedure was developed during this study. This inspection procedure is included in the appendix. It suggests a method of determining the major users of electrical energy in a building, how to inspect individual buildings, how to evaluate inspection results, and suggests a checklist to use during building inspections.

5 CONCLUSIONS

1. Seventy percent of the electrical energy used on the Army installations studied is being consumed on a continuous (baseline) basis; only 30 percent of the total energy consumption is caused by building occupancy and installation daily operations.

2. Up to 75 percent of a building's annual consumption is caused by its minimum hourly usage (demand). A large portion of this usage is directly attributed to HVAC system operation.

3. The most effective way to reduce electrical energy consumption on Army installations is to reduce the minimum hourly usage (demand) of individual installation buildings. This can be done by analyzing and optimizing HVAC system and building operation. For example, if the minimum hourly usage (demand) of a typical bachelor housing facility is reduced by 1 kW/hour, the facility's overall electrical energy consumption will decrease by 5 percent.

Table 1

Building Locations and Functions

Fort Belvoir Building No.	
203	Bachelor Enlisted Quarters (Barracks)
2111	Bachelor Enlisted Quarters (Modular Barracks)
508	Bachelor Officers Quarters (BOQ)
216	Administrative Building
20	Officer's Open Dining Facility
2120	Post Theater
1200	Enlisted Open Dining Facility
1949	Motor Pool
1099	Dental Clinic

Fort Carson Building No.	
811	Bachelor Enlisted Quarters w/Dining Facilities (Barracks)
1044	Bachelor Enlisted Quarters (Barracks)
1219	Bachelor Enlisted Quarters w/Dining Facilities (Barracks)
1951	Bachelor Enlisted Quarters (Modular Barracks)
7304	Bachelor Officers Quarters (BOQ)
1430	Administrative Building
1230	Recreation Center
7300	Officer's Open Dining Facility
1525	Commissary
2492	Maintenance Shop
2992	Maintenance Shop

Table 2

Monthly Feeder Electrical Consumption -- July 1976 through June 1977

	Feeder 1	Feeder 2	Feeder 3	Feeder 4	Feeder 5	Feeder 6	Feeder 7	Feeder 8	Total
JUL 76	789,500	459,600	496,300	940,000	837,100	369,400	348,500	665,000	4,905,400
AUG 76	736,700	465,600	489,300	936,800	809,400	373,300	654,600	454,100	4,919,800
SEP 76	684,800	478,400	496,200	876,800	745,000	411,600	603,100	549,900	4,845,800
OCT 76	716,800	523,600	518,100	852,300	709,600	439,400	602,300	630,200	4,992,300
NOV 76	723,200	552,600	545,800	822,200	662,100	470,100	610,500	653,000	5,039,500
DEC 76	779,300	558,600	612,400	851,100	658,600	473,200	622,600	686,600	5,242,400
JAN 77	805,100	466,400	568,600	839,500	679,400	506,100	659,100	743,500	5,267,700
FEB 77	736,700	389,700	488,500	700,100	599,000	431,300	573,100	635,200	4,562,600
MAR 77	746,100	537,000	523,200	721,600	534,000	455,700	611,200	675,100	4,803,900
APR 77	722,900	482,000	479,100	681,700	479,300	400,600	561,400	570,600	4,377,600
MAY 77	713,900	473,600	452,100	697,700	499,100	381,800	550,000	526,700	4,294,900
JUN 77	800,400	434,700	423,000	608,100	576,100	359,000	548,500	551,400	4,301,200

Table 3

Monthly Feeder Electrical Consumption -- July 1977 through June 1978

FY78	Feeder 1	Feeder 2	Feeder 3	Feeder 4	Feeder 5	Feeder 6	Feeder 7	Feeder 8	Total
JUL 77	818,600	509,200	338,200	303,000	628,200	356,600	582,500	579,900	4,116,200
AUG 77	--	--	--	--	--	--	--	--	--
SEP 77	712,000	451,700	--	--	532,400	319,100	485,660	550,100	--
OCT 77	693,300	--	454,600	--	491,100	136,700	345,600	585,000	--
NOV 77	704,900	580,800	131,700	1,030,700	505,100	489,500	675,600	649,900	4,776,200
DEC 77	695,400	590,200	443,300	758,000	584,100	508,000	715,400	665,500	4,959,900
JAN 78	709,100	570,100	554,700	831,100	555,800	579,800	732,400	791,900	5,324,900
FEB 78	632,900	533,200	471,300	668,700	464,300	485,800	648,700	684,800	4,689,700
MAR 78	696,500	590,800	493,800	699,900	508,700	485,100	680,000	700,400	4,855,200
APR 78	668,400	640,600	414,100	660,100	474,700	406,000	620,400	580,400	4,464,700
MAY 78	692,900	569,300	414,100	723,200	509,600	--	--	--	--
JUN 78	781,900	499,400	387,000	793,200	587,400	284,653	--	--	--

Table 4

Daily Feeder Electrical Consumption

	Feeder 1	Feeder 2	Feeder 3	Feeder 4	Feeder 5	Feeder 6	Feeder 7	Feeder 8
<u>Winter</u>								
15 JAN 78 (Sunday)								
Consumption	17,980	16,950	18,670	26,740	13,230	15,770	23,150	23,930
MAX demand	899	1,029	1,140	1,248	720	1,025	1,046	1,177
MIN demand	629	480	449	1,019	425	487	821	763
% of daily	84	68	58	91	77	74	85	77
17 JAN 78 (Tuesday)								
Consumption	25,380	18,950	23,960	32,520	17,660	18,960	24,350	24,470
MAX demand	1,287	1,044	1,370	1,569	1,022	1,233	1,140	1,223
MIN demand	684	518	666	1,072	438	497	870	689
% of daily	65	66	67	79	60	63	86	68
<u>Summer</u>								
11 JUN 78 (Sunday)								
Consumption	20,950	15,430	7,780	22,900	15,450	8,800	--	--
MAX demand	1,002	1,060	567	1,130	809	531	--	--
MIN demand	672	422	234	769	514	265	--	--
% of daily	77	66	72	81	80	72	--	--
13 JUN 78 (Tuesday)								
Consumption	29,750	18,460	15,560	28,540	21,400	12,680	--	--
MAX demand	1,538	1,076	1,011	1,388	1,235	774	--	--
MIN demand	840	556	348	973	527	320	--	--
% of daily	68	72	54	82	59	61	--	--

Table 5

Fort Carson Weather Parameters

Date	MAX Temperature °F(°C)	MIN Temperature °F(°C)	Average Temperature °F(°C)	HDD	CDD
15 Jan 78	36 (2.2)	16 (-8.8)	26 (-3.3)	39	0
17 Jan 78	42 (5.5)	3 (-16.1)	23 (-5)	42	0
11 Jun 78	76 (24.4)	56 (12.3)	66 (18.8)	--	1
13 Jun 78	88 (31.1)	51 (10.5)	70 (21.1)	--	5

Table 6

Weather Parameters (Daily Data)

Date	MAX Temperature °F(°C)	MIN Temperature °F(°C)	Average Temperature °F(°C)	HDD	CDD
		Fort Carson			
14 Jan 78	35 (1.6)	14 (-10)	25 (-3.8)	40	0
15 Jan 78	36 (2.2)	16 (-8.8)	26 (-3.3)	39	0
17 Jan 78	42 (5.5)	3 (-16.1)	23 (-5)	42	0
18 Jan 78	31 (-0.5)	16 (-8.8)	24 (-4.4)	41	0
17 Jun 78	80 (26.6)	56 (13.3)	68 (20)	0	3
18 Jun 78	74 (23.3)	55 (12.7)	65 (18.3)	0	0
20 Jun 78	70 (21.1)	49 (9.4)	60 (15.5)	5	0
21 Jun 78	89 (31.6)	57 (13.8)	73 (22.7)	0	8
		Fort Belvoir			
14 Jan 78	37 (2.7)	31 (-0.5)	34 (0.1)	31	0
15 Jan 78	33 (0.5)	24 (-4.4)	29 (-1.6)	36	0
17 Jan 78	38 (3.3)	31 (-0.5)	35 (1.6)	30	0
18 Jan 78	40 (4.4)	29 (-1.6)	35 (1.6)	30	0
17 Jun 78	78 (25.5)	70 (21.1)	74 (23.3)	0	9
18 Jun 78	94 (34.4)	71 (21.6)	83 (28.3)	0	18
20 Jun 78	88 (31.1)	69 (20.5)	79 (26.1)	0	14
21 Jun 78	88 (31.1)	70 (21.1)	79 (26.1)	0	14

Table 7

Heating and Cooling Degree Days

	Fort Carson		Fort Belvoir	
	HDD	CDD	HDD	CDD
JUL 76	0	227	0	424
AUG	11	114	0	370
SEP	191	28	11	179
OCT	503	0	306	15
NOV	859	0	652	0
DEC	988	0	907	0
JAN 77	1181	0	1221	0
FEB	837	0	729	0
MAR	858	0	389	10
APR	494	0	188	49
MAY	192	0	32	177
JUN	5	103	3	289
JUL	2	204	0	496
AUG	22	142	0	434
SEP	73	49	1	274
OCT	413	0	196	18
NOV	784	0	406	15
DEC	938	0	829	0
JAN 78	1231	0	1001	0
FEB	1036	0	933	0
MAR	741	0	633	0
APR	479	0	219	10
MAY	386	4	86	117
JUN	98	143	0	358

Table 8

Building 1430 -- Fort Carson

Building Function: Administration　　Location: Fort Carson　　Year Built: 1957

Building Number: 1430　　Floor Area: 41,180 sq ft

BUILDING EQUIPMENT Type/Description	Approximate Connected Load
Lighting	
Incandescent	7.9
Fluorescent	43.8
HVAC	
Air conditioning	19.0
Pumps	1.0
Fans	9.9
Other Equipment	
Typewriters	8.6
Copiers	13.8
Word processing	1.8
Telecommunications	50.0
Vending	3.1
Audio visual	5.3
Miscellaneous	12.2

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	43,900
Aug	--	40,940
Sep	--	36,880
Oct	--	36,330
Nov	38,720	39,100
Dec	40,520	39,560
Jan	40,330	37,720
Feb	36,890	--
Mar	39,550	37,530
Apr	37,580	39,340
May	36,120	41,430
Jun	43,710	43,840

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	1040	41	47	905	34	41
18 Jun 78/15 Jan 78 (Sun)	1007	38	46	841	33	38
20 Jun 78/17 Jan 78 (Tues)	1671	41	101	1522	31	91
21 Jun 78/18 Jan 78 (Wed)	1688	38	108	1551	32	95

Comments:

Administrative Building--office occupancy for typical work week. Time range approximately 7:30 AM to 4:15 PM. Estimated 50 hours/week occupancy including janitorial.

Lighting--25% on corridors; 75% to 100% on offices.

Cooling accomplished by individual window units (12 kW) and central unit for selected spaces.

Table 9

Building 7300 -- Fort Carson

Building Function: Officer's open mess Location: Fort Carson Year Built: ___

Building Number: 7300 Floor Area: 19,089 sq ft

BUILDING EQUIPMENT Type/Description	Approximate Connected Load
Lights	
Incandescent	4.0
Fluorescent	14.7
HVAC	
Refrigeration (AC)	48
Fans	18.5
Other Equipment	
Refrigeration	20.5
Food Preparation	5.0
Miscellaneous	4.5

MONTHLY CONSUMPTION (kWh)	1976-1977	1977-1978
Jul	--	56,940
Aug	--	53,130
Sep	--	42,500
Oct	--	38,640
Nov	--	33,160
Dec	34,690	34,760
Jan	39,750	32,590
Feb	35,770	33,580
Mar	40,580	35,740
Apr	39,620	36,740
May	42,190	40,210
Jun	57,000	52,070

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	1691	42	90	1063	25	61
18 Jun 78/15 Jan 78 (Sun)	1267	30	80	723	18	56
20 Jun 78/17 Jan 78 (Tues)	1599	37	93	1084	22	75
21 Jun 78/18 Jan 78 (Wed)	1733	39	102	1045	22	71

Comments:

Officers open dining facility--occupancy generally in evening from 5 PM to 12 PM.

Cooling is accomplished by roof-mounted AC units.

Table 10

Building 1525 -- Fort Carson

Building Function: Commissary   Location: Fort Carson   Year Built: 1974

Building Number: 1525   Floor Area: 81,455 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lights	
Fluorescent	37.0
Incandescent	10.2
HVAC	
Air handling units	32.4
Fans	38.5
Pumps	5.1
Unit heaters	2.9
Refrigeration	138.8
Produce & meat preparation	26.9
Other Equipment	
Battery chargers	8.0
Cash registers	2.3
Miscellaneous	3.5

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	260,840
Aug	--	251,040
Sep	--	227,130
Oct	--	202,810
Nov	232,250	162,960
Dec	236,130	216,360
Jan	240,480	226,180
Feb	219,720	205,620
Mar	234,360	233,920
Apr	237,910	225,170
May	234,360	238,220
Jun	260,770	265,610

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	8780	221	495	7780	222	385
18 Jun 78/15 Jan 78 (Sun)	7010	219	362	5620	220	302
20 Jun 78/17 Jan 78 (Tues)	9200	247	455	7910	219	296
21 Jun 78/18 Jan 78 (Wed)	9580	256	492	7910	227	390

Comments:

Commissary Hours of Operation: 9 AM to 6 PM Weekdays; 9 AM to 5 PM Saturdays.

Night crews working use about 45% lighting (fluorescent).

Produce and meat preparation = 8 hours/day 5 days/week.

Cooling load includes both AC (about 100 ton) and process refrigeration.

Table 11

Building 7304 -- Fort Carson

Building Function: BOQ

Location: Fort Carson

Year Built: 1970

Building Number: 7304

Floor Area: 37,100 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lights	
Incandescent	2.1
Fluorescent	4.4
Outside	0.70
HVAC	
Pumps	2.8
Fans	12.0
Other Equipment	
Laundry	29.6
Refrigeration	7.6
Miscellaneous	0.6

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	12,887	8,588
Aug	13,232	NA
Sep	13,476	13,471
Oct	15,211	NA
Nov	16,051	15,795
Dec	16,315	15,677
Jan	18,511	17,936
Feb	16,455	14,998
Mar	17,929	16,619
Apr	16,418	16,171
May	15,578	16,484
Jun	13,533	14,488

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	486	16	26	647	20	36
18 Jun 78/15 Jan 78 (Sun)	516	15	29	555	18	33
20 Jun 78/17 Jan 78 (Tues)	469	14	31	670	17	46
21 Jun 78/18 Jan 78 (Wed)	456	14	25	585	15	40

Comments:

BOQ facility peak occupancy late early and early morning from about 6 PM to 6 AM.

BOQ capacity -- 77 rooms.

Rooms contain individual exhaust fans.

Table 12

Building 1953 -- Fort Carson

Building Function: BEQ — Location: Fort Carson — Year Built: 1974

Building Number: 1953 — Floor Area: 21,280 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lights	
Incandescent	9.8
Fluorescent	4.0
HVAC	
Pumps	4.5
Fans	11.3
Other Equipment	
Laundry	15.1
Miscellaneous	0.4

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	9,597
Aug	--	10,577
Sep	--	9,466
Oct	--	11,756
Nov	12,274	11,734
Dec	12,456	12,611
Jan	13,941	13,509
Feb	11,881	12,796
Mar	12,995	13,320
Apr	11,126	11,580
May	10,745	10,872
Jun	10,358	11,077

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	361	12	19	423	14	25
18 Jun 78/15 Jan 78 (Sun)	398	12	21	463	14	25
20 Jun 78/17 Jan 78 (Tues)	356	9	23	397	14	23
21 Jun 78/18 Jan 78 (Wed)	381	12	22	421	13	27

Comments:

Barracks facility peak occupancy from 6 PM to 6 AM.

Cooling is accomplished by chilled water from central plant. Fan coil units in individual rooms, corridors and lounges.

Table 13

Building 811 -- Fort Carson

Building Function: BEQ w/dining Location: Fort Carson Year Built: 1956

Building Number: 811 Floor Area: 40,427 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lighting	
Incandescent	6.3
Fluorescent	12.3
HVAC	
Pumps	14.3
Fans	7.5
Mess Facility	
Refrigeration	10.0
Food preparation	13.3
Barracks Facility	
Laundry	26.8
Miscellaneous	4.4

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	22,060
Aug	--	22,170
Sep	--	21,420
Oct	--	18,470
Nov	22,030	18,780
Dec	19,720	16,310
Jan	21,630	18,430
Feb	19,370	14,530
Mar	18,530	15,130
Apr	20,210	11,470
May	18,370	--
Jun	19,390	--

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	702	20	36	656	20	32
18 Jun 78/15 Jan 78 (Sun)	635	22	31	645	18	32
20 Jun 78/17 Jan 78 (Tues)	888	28	43	615	18	31
21 Jun 78/18 Jan 78 (Wed)	881	27	43	645	17	33

Comments:

Barracks facility peak occupancy essentially from 6 PM to 6 AM.
Dining facility -- 3 meals/day (Monday through Friday).
Barracks capacity -- about 178 personnel.
Cooling accomplished by chilled water from central plant.

Table 14

Building 1219 -- Fort Carson

Building Function: BEQ   Location: Fort Carson   Year Built: 1958

Building Number: 1219   Floor Area: 51,760 sq ft

BUILDING EQUIPMENT Type/Description	Approximate Connected Load		MONTHLY CONSUMPTION (kWh) 1976-1977	1977-1978
Lighting		Jul	--	14,090
Incandescent	19.5	Aug	--	15,190
Fluorescent	6.5	Sep	--	14,280
HVAC		Oct	--	15,210
Pumps	9.3	Nov	17,160	16,060
Fans	4.7	Dec	14,410	14,420
Mess Facility		Jan	17,470	15,750
Refrigeration	6.1	Feb	15,070	13,640
Food Preparation	12.0	Mar	15,490	14,720
Barracks Facility		Apr	14,890	13,630
Laundry	16.5	May	14,440	14,510
Miscellaneous	4.1	Jun	14,760	13,530

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	297	10	16	411	15	21
18 Jun 78/15 Jan 78 (Sun)	309	11	16	440	14	23
20 Jun 78/17 Jan 78 (Tues)	541	17	28	570	13	31
21 Jun 78/18 Jan 78 (Wed)	492	12	28	570	16	31

Comments:

Barracks facility peak occupancy essentially from 6 PM to 6 AM.
Dining facility -- 3 meals/day (Monday through Friday).

Table 15

Building 1971 -- Fort Carson

Building Function: BEQ Location: Fort Carson Year Built: 1971

Building Number: 1044 Floor Area: 42,683 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lighting	
Incandescent	0.9
Fluorescent	13.2
HVAC	
Pumps	7.0
Fans	13.0
Air Conditioning	38.2
Other Equipment	
Laundry	30.0
Miscellaneous	4.6

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	25,080	20,770
Aug	28,150	11,030
Sep	21,170	10,630
Oct	15,460	11,760
Nov	15,890	11,730
Dec	14,040	11,010
Jan	12,680	11,620
Feb	11,250	9,920
Mar	11,410	10,550
Apr	11,420	10,590
May	10,840	10,760
Jun	14,360	14,690

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	535	18	28	356	10	20
18 Jun 78/15 Jan 78 (Sun)	437	10	28	357	8	21
20 Jun 78/17 Jan 78 (Tues)	472	8	30	383	10	31
21 Jun 78/18 Jan 78 (Wed)	393	11	31	312	7	18

Comments:

Barracks facility peak occupancy from 6 PM to 6 AM.
No dining facilities.
Barracks capacity -- about 217 personnel.
Cooling is supplied by central plant.

Table 16

Building 1230 -- Fort Carson

Building Function: Recreation center   Location: Fort Carson   Year Built: 1959

Building Number: 1230   Floor Area: 26,732 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lights	
Incandescent	9.1
Fluorescent	12.8
HVAC	
Fans	16.4
Pumps	3.1
Other Equipment	
Stage lighting	15.0
Office	2.0
Vending	2.7
Miscellaneous	4.7

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	19,160
Aug	--	21,470
Sep	--	16,210
Oct	--	--
Nov	11,540	10,320
Dec	11,730	11,560
Jan	12,030	9,970
Feb	11,060	--
Mar	10,730	10,490
Apr	9,440	9,920
May	8,420	10,520
Jun	16,410	--

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	377	9	28	303	7	23
18 Jun 78/15 Jan 78 (Sun)	334	9	26	313	7	28
20 Jun 78/17 Jan 78 (Tues)	354	10	24	356	9	25
21 Jun 78/18 Jan 78 (Wed)	370	10	23	369	9	28

Comments:

Building is used as recreational center from 5:30 PM to 10:00 PM Monday through Thursday and 1 PM to 10 PM Saturday and Sunday. Building open for regular staff use 7 AM to 10 PM (daily).

Table 17

Building 2492 -- Fort Carson

Building Function: Maintenance

Location: Fort Carson

Year Built: 1966

Building Number: 2492

Floor Area: 21,060 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lighting	
Incandescent	6.3
Fluorescent	17.9
Outside	3.9
HVAC	
Units heaters	13.2
Exhaust fans	2.2
Other	
Door motors	6.1
Air compressor	12.2
Miscellaneous	2.4

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	10,430	14,920
Aug	8,620	15,550
Sep	16,830	18,520
Oct	22,270	23,720
Nov	26,030	25,850
Dec	28,170	28,910
Jan	32,160	34,510
Feb	24,030	30,640
Mar	24,010	28,850
Apr	19,680	23,150
May	18,120	19,230
Jun	14,770	18,120

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	346	10	24	1101	42	53
18 Jun 78/15 Jan 78 (Sun)	368	9	24	1065	43	46
20 Jun 78/17 Jan 78 (Tues)	727	19	43	1209	42	61
21 Jun 78/18 Jan 78 (Wed)	694	21	35	1360	44	70

Comments:

Motor pool hours of operation -- 7:30 AM to 4:30 PM, 5 days/week.

Intermittent operation -- motor pool shutdown if units are out in field, etc.

Equipment and usage similar for Buildings 2492 and 2992.

Portable generators used for welding equipment.

Table 18

Building 2992 -- Fort Carson

Building Function: Maintenance   Location: Fort Carson   Year Built: 1966

Building Number: 2992   Floor Area: 21,060 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lighting	
Incandescent	6.3
Fluorescent	17.9
Outside	3.9
HVAC	
Units heaters	13.2
Exhaust fans	2.2
Other	
Door Motors	6.1
Air compressor	12.2
Miscellaneous	2.4

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	14,910	10,022
Aug	13,730	--
Sep	17,010	--
Oct	20,990	--
Nov	21,160	14,990
Dec	22,990	19,010
Jan	21,360	19,890
Feb	21,420	17,600
Mar	24,050	15,890
Apr	20,250	15,390
May	11,423	14,900
Jun	6,760	11,410

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	171	3	15	418	16	19
18 Jun 78/15 Jan 78 (Sun)	207	3	15	414	15	18
20 Jun 78/17 Jan 78 (Tues)	405	5	30	872	26	49
21 Jun 78/18 Jan 78 (Wed)	360	6	31	937	30	50

Comments:

Motor pool hours of operation -- 7:30 AM to 4:30 PM, 5 days/week.

Intermittent operation -- motor pool shutdown if units are out in field, etc.

Equipment and usage similar for Buildings 2492 and 2992.

Portable generators used for welding equipment.

Table 19

Building 216 -- Fort Belvoir

Building Function: Administration　　Location: Fort Belvoir　　Year Built: 1932

Building Number: 216　　Floor Area: 23,513 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lighting	
Incandescent	0.2
Fluorescent	34.0
HVAC	
Refrigeration	16.5
Fans	0.7
Pumps	6.7
Other Equipment	
Copier	2.9
Miscellaneous	2.4

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	NA	--
Aug	NA	--
Sep	NA	--
Oct	NA	--
Nov	NA	10,480
Dec	NA	10,470
Jan	NA	10,890
Feb	NA	9,920
Mar	NA	12,120
Apr	NA	9,530
May	NA	9,560
Jun	NA	--

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	66	2.4	3	245	7	26
18 Jun 78/15 Jan 78 (Sun)	68	3.0	4	188	7	9
20 Jun 78/17 Jan 78 (Tues)	388	3	37	482	8	44
21 Jun 78/18 Jan 78 (Wed)	380	3	35	457	8	42

Comments:

Administrative building typical hours operations 7:30 AM to 4:15 PM (Monday through Friday).

Individual offices cooled with window air conditioning units (about 10 kW). Central unit cools selected areas such as conference room (8 ton).

Table 20

Building 20 -- Fort Belvoir

Building Function: Officer's open mess Location: Fort Belvoir Year Built: 1954

Building Number: 20 Floor Area: 66,972 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lighting	
Incandescent	66.4
Fluorescent	19.3
HVAC	
Refrigeration (AC)	145
Fans	66.5
Pumps	20.7
Heaters	11.6
Miscellaneous	9.4
Other Equipment	
Refrigeration	72.1
Food preparation	13.9
Elevators	26.7
Pool	15.7
Miscellaneous	16.5

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	159,220
Aug	--	162,480
Sep	126,240	135,410
Oct	104,680	90,870
Nov	89,280	86,440
Dec	--	90,790
Jan	88,680	84,190
Feb	72,490	68,990
Mar	75,450	73,460
Apr	82,990	66,820
May	109,010	91,030
Jun	117,790	128,230

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	4527	137	241	2719	96	139
18 Jun 78/15 Jan 78 (Sun)	4739	143	232	2590	96	121
20 Jun 78/17 Jan 78 (Tues)	4389	118	247	2819	93	152
21 Jun 78/18 Jan 78 (Wed)	4469	123	250	2948	93	149

Comments:

Officers open dining facility--occupancy generally in evening from 5 to 12 PM.

Guest facilities occupancy essentially late evening to early morning from 6 PM to 6 AM.

Cooling accomplished with two 100-ton units. Quarters are cooled with individual window units (about 23 kW).

Table 21

Building 1099 -- Fort Belvoir

Building Function: Dental clinic   Location: Fort Belvoir   Year Built: 1970

Building Number: 1099   Floor Area: 14,188 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lighting	
Incandescent	3.8
Fluorescent	3.3
HVAC	
Refrigeration (AC)	31.6
Fans	12.3
Pumps	3.6
Other Equipment	
Compressors	12.2
Pumps (vacuum)	12.4
Prosthetics (29 rooms)	56.7
X-ray	2.1
Sterilization	7.4
Lab	13.3
Miscellaneous	13.0

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	26,080
Aug	--	29,470
Sep	12,930	28,660
Oct	15,800	13,500
Nov	14,400	14,220
Dec	13,750	14,210
Jan	13,540	13,690
Feb	12,660	13,930
Mar	13,910	16,840
Apr	11,930	14,440
May	18,970	14,990
Jun	21,760	27,060

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	670	19	34	207	8	9
18 Jun 78/15 Jan 78 (Sun)	760	21	40	207	8	9
20 Jun 78/17 Jan 78 (Tues)	933	10	65	506	8	38
21 Jun 78/18 Jan 78 (Wed)	1009	10	65	501	8	37

Comments:

Dental Clinic hours of operation -- 7:30 AM to 4:00 PM (Monday through Friday).

Cooling accomplished with 50-ton AC unit.

Table 22

Building 2120 -- Fort Belvoir

Building Function: Theatre   Location: Fort Belvoir   Year Built: ____

Building Number: 2120   Floor Area: 10,650 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lighting	
Incandescent	12.2
Fluorescent	0.9
HVAC	
Refrigeration (AC)	18.0
Fans	11.5
Pumps	2.3
Other Equipment	
Projector	4.0
Hand dryers	8.8
Miscellaneous	5.8

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	21,310
Aug	--	13,910
Sep	--	8,460
Oct	7,150	6,120
Nov	7,425	9,570
Dec	--	9,440
Jan	10,235	9,520
Feb	7,650	9,470
Mar	5,980	9,760
Apr	--	8,860
May	5,980	3,160
Jun	10,033	5,460

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	94	2	9	320	11	18
18 Jun 78/15 Jan 78 (Sun)	122	2	10	316	11	17
20 Jun 78/17 Jan 78 (Tues)	434	2	47	310	11	17
21 Jun 78/18 Jan 78 (Wed)	284	2	39	--	--	--

Comments:

Theater facility involves evening occupancy from 6 to 12 PM.
Cooling accomplished by two 15-ton AC.

Table 23

Building 508 -- Fort Belvoir

Building Function: BOQ   Location: Fort Belvoir   Year Built: 1969

Building Number: 508   Floor Area: 18,360 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lights	
Incandescent	18.6
Fluorescent	3.4
HVAC	
Refrigeration	9.7
Pumps	4.0
Fans	8.7
Other Equipment	
Refrigeration	30.2
Miscellaneous	3.4

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	14,250
Aug	--	12,490
Sep	11,620	8,830
Oct	8,930	4,400
Nov	8,910	5,000
Dec	8,610	5,320
Jan	7,980	6,110
Feb	6,370	5,590
Mar	6,410	5,710
Apr	4,170	5,860
May	4,200	4,590
Jun	9,080	7,480

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	311	10	17	188	5	11
18 Jun 78/15 Jan 78 (Sun)	415	9	32	190	4	12
20 Jun 78/17 Jan 78 (Tues)	341	10	18	169	4	13
21 Jun 78/18 Jan 78 (Wed)	330	9	14	149	4	11

Comments:

Bachelor officer's quarters facility peak occupancy from 6 PM to 6 AM.
Capacity -- 42 personnel.
Cooling is accomplished with a 20-ton AC unit.

Table 24

Building 211 -- Fort Belvoir

Building Function: BEQ

Location: Fort Belvoir

Year Built: 1975

Building Number: 2111

Floor Area: 19,320 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lights	
Incandescent	14.4
Fluorescent	1.4
HVAC	
Pumps	7.6
Fans	12.6
Other Equipment	
Laundry	24.6
Refrigeration	3.8
Miscellaneous	3.3

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	6,880
Aug	--	6,260
Sep	4,680	7,750
Oct	5,810	8,130
Nov	6,770	8,460
Dec	7,380	9,020
Jan	7,690	9,560
Feb	7,220	8,530
Mar	8,240	8,840
Apr	6,910	8,150
May	6,330	6,780
Jun	7,010	7,140

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	247	8	14	312	8	19
18 Jun 78/15 Jan 78 (Sun)	290	8	20	325	8	20
20 Jun 78/17 Jan 78 (Tues)	250	8	18	311	8	21
21 Jun 78/18 Jan 78 (Wed)	228	6	16	274	8	21

Comments:

Enlisted barracks facility peak occupancy from 6 PM to 6 AM.

Barracks capacity -- 132 personnel

Cooling accomplished by fan coil units with chilled water from a central plant.

Table 25

Building 1928 -- Fort Belvoir

Building Function: BEQ — Location: Fort Belvoir — Year Built: 1928

Building Number: 203 — Floor Area: 24,331 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lighting	
Incandescent	10.9
Fluorescent	15.0
HVAC	
Refrigeration	21.0
Miscellaneous	1.9
Other	
Laundry	14.8
Miscellaneous	3.5

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	14,760
Aug	--	14,650
Sep	6,780	11,310
Oct	6,980	6,920
Nov	7,400	6,030
Dec	7,850	5,550
Jan	8,680	6,930
Feb	7,460	7,250
Mar	8,080	6,900
Apr	6,800	4,620
May	7,090	3,820
Jun	8,510	6,610

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	199	7	11	244	7	13
18 Jun 78/15 Jan 78 (Sun)	187	6	10	235	7	12
20 Jun 78/17 Jan 78 (Tues)	333	7	24	241	7	15
21 Jun 78/18 Jan 78 (Wed)	392	5	21	231	7	14

Comments:

Barracks facility peak occupancy essentially from 6 AM to 6 PM.
Barracks capacity -- 68 personnel.
Cooling accomplished with a 40-ton AC unit.

Table 26

Building 1200 -- Fort Belvoir

Building Function: Enlisted dining   Location: Fort Belvoir   Year Built: 1965

Building Number: 1200   Floor Area: 24,045 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lights	
Incandescent	19.7
Fluorescent	11.5
HVAC	
Refrigeration	66.0
Fans	26.0
Pumps	19.4
Other Equipment	
Refrigeration	38.3
Food Preparation	13.7
Miscellaneous	12.5

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	20,900
Aug	--	19,570
Sep	19,040	13,720
Oct	18,770	13,780
Nov	20,110	18,800
Dec	--	22,850
Jan	20,600	20,340
Feb	18,810	18,480
Mar	22,500	19,560
Apr	20,890	19,000
May	20,760	21,310
Jun	--	20,140

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	737	20	37	718	23	35
18 Jun 78/15 Jan 78 (Sun)	727	21	37	645	22	35
20 Jun 78/17 Jan 78 (Tues)	624	19	36	580	22	32
21 Jun 78/18 Jan 78 (Wed)	535	18	32	655	19	34

Comments:

Enlisted open dining facility occupancy generally from 5 to 12 PM.
Cooling accomplished by 100-ton AC unit.

Table 27

Building 1949 -- Fort Belvoir

Building Function: Motor pool   Location: Fort Belvoir   Year Built: 1963

Building Number: 1949   Floor Area: 11,235 sq ft

BUILDING EQUIPMENT

Type/Description	Approximate Connected Load
Lights	
Incandescent	1.1
Fluorescent	10.9
HVAC	
Fans	10.8
Unit heaters	1.6
Other Equipment	
Air compressor	5.6
Door motors	3.3
Water heater	4.5
Miscellaneous	4.1

MONTHLY CONSUMPTION (kWh)

	1976-1977	1977-1978
Jul	--	2,560
Aug	--	3,760
Sep	--	3,820
Oct	--	3,430
Nov	--	3,880
Dec	--	4,210
Jan	5,330	5.060
Feb	4,100	5,300
Mar	4,290	5,540
Apr	3,400	3,900
May	3,930	5,400
Jun	2,560	4,210

SEASONAL CONSUMPTION (kWh)

	Summer			Winter		
	Daily	Hourly MIN	Hourly MAX	Daily	Hourly MIN	Hourly MAX
17 Jun 78/14 Jan 78 (Sat)	12	.2	1	120	5	5
18 Jun 78/15 Jan 78 (Sun)	13	.2	4	122	5	5
20 Jun 78/17 Jan 78 (Tues)	140	.3	15	258	3	21
21 Jun 78/18 Jan 78 (Wed)	132	.5	14	220	2	24

Comments:

Motor pool hours of operation from 7 AM to 5 PM (Monday through Friday).

Table 28

Fort Belvoir -- Electrical Energy Consumption
(in MWh x 10^3) for FY77 to FY79

	FY77	FY78	FY79
OCT	6016	5888	7134
NOV	6080	6464	5248
DEC	6400	6112	6624
JAN	6048	6592	6240
FEB	5568	5152	7008
MAR	5856	6592	5280
APR	5792	6016	5856
MAY	5472	5440	6016
JUN	6880	6944	--
JUL	9184	8800	--
AUG	9760	10,688	--
SEP	9088	8480	--

Total: FY77 = 82,144 MWh
FY78 = 83,168 MWh

Table 29

Fort Carson -- Electrical Energy Consumption
(in MWh x 10^3) for FY77 to FY79

	FY77	FY78	FY79
OCT	6118	5833	5555
NOV	6203	6162	5994
DEC	6189	5812	6584
JAN	6844	6845	6224
FEB	6457	6419	6000
MAR	5563	5608	5432
APR	5874	5986	6038
MAY	5414	5606	--
JUN	6374	5452	--
JUL	5752	6286	--
AUG	5804	6338	--
SEP	5203	5735	--

Total: FY77 = 71,795,600 MWh
FY78 = 72,085,150 MWh

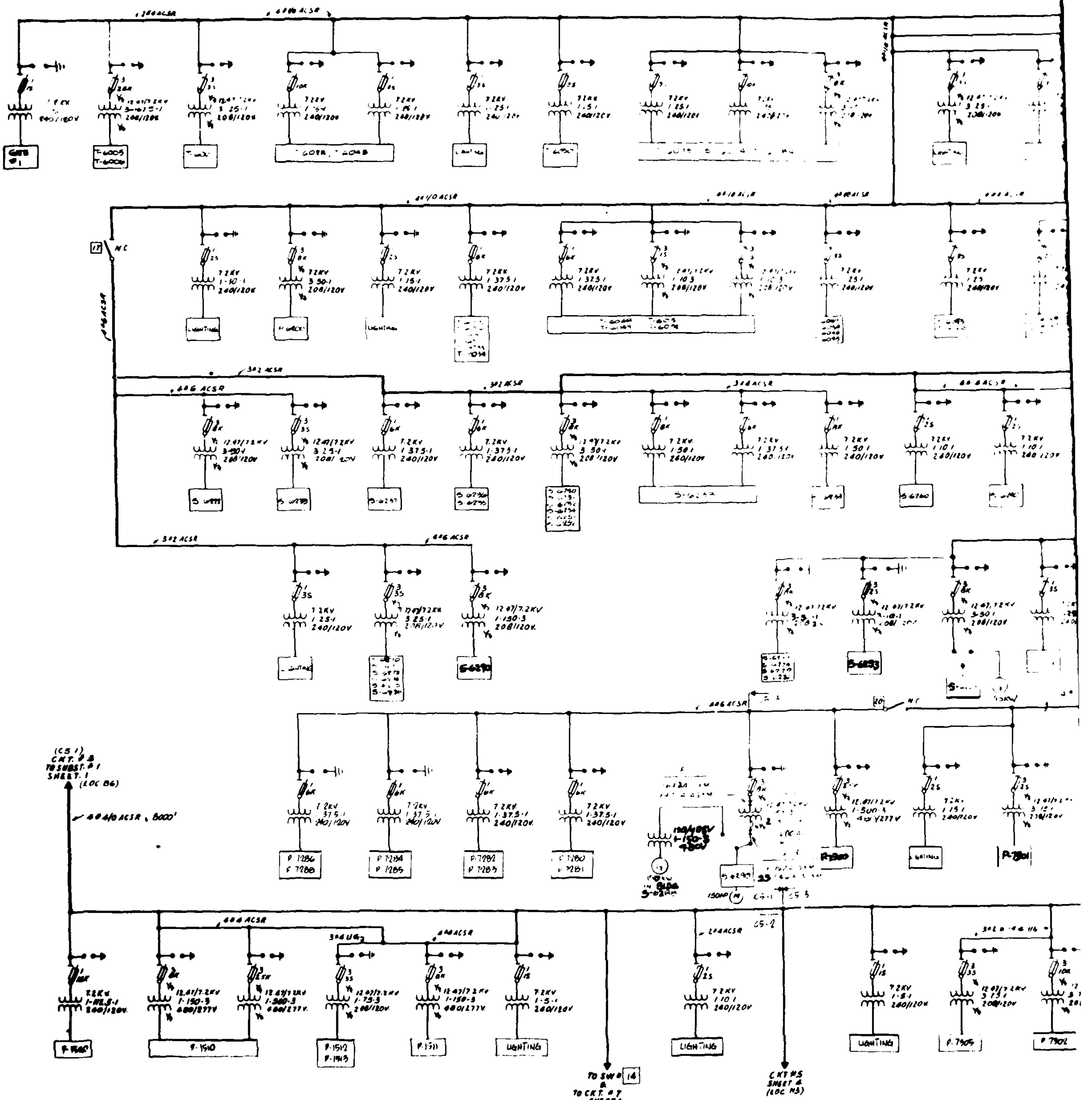
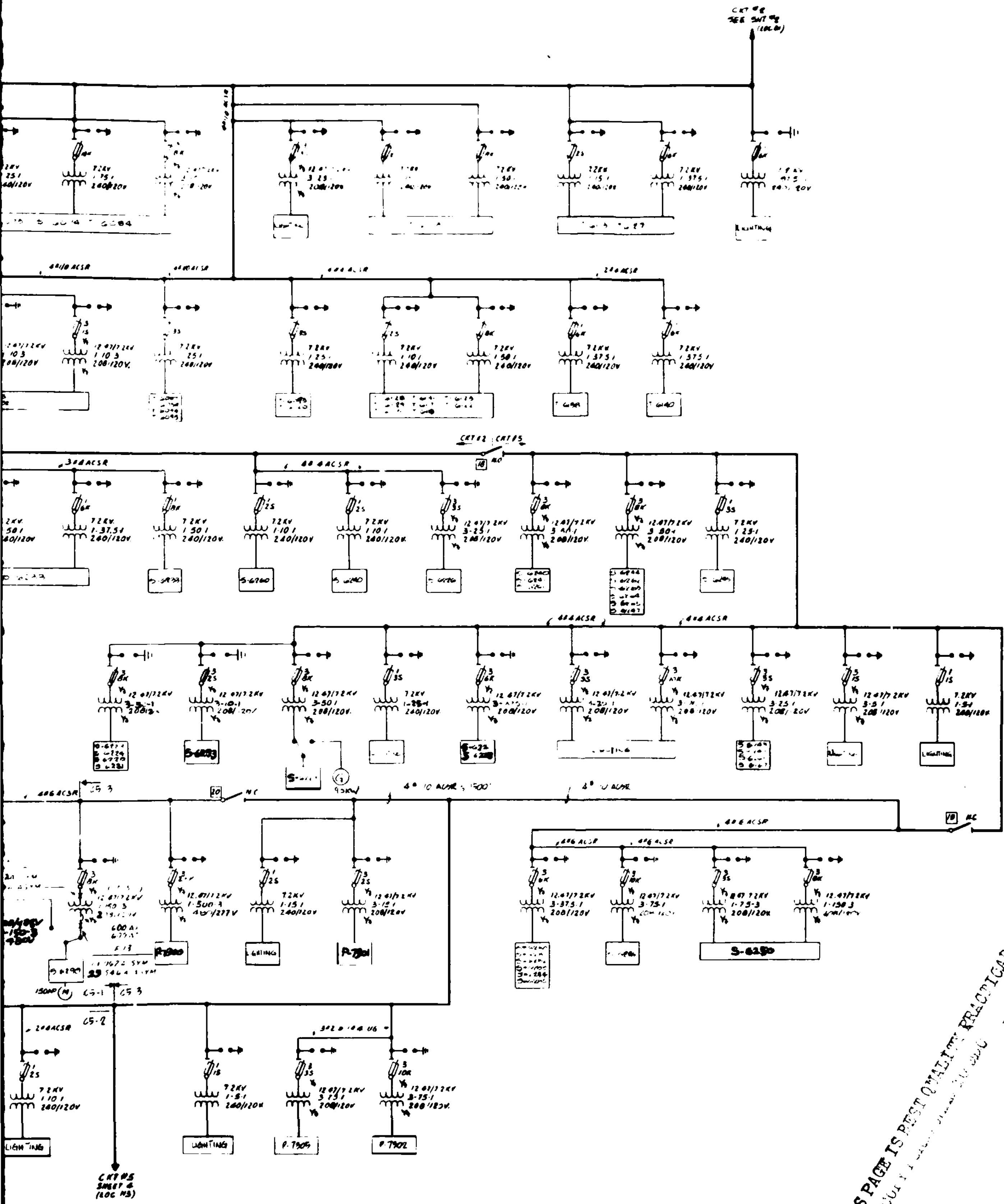


Figure 1. Fort Carson electrical distribution system.


CKT #5
SHEET 6
(LOC H3)
LIGHTING
S-6250
S-6283
S-6260
P-7901
P-7902
P-7905
CKT #2
CKT #5
4#6 ACSR
4#4 ACSR
12.47/7.2KV
208/120V
240/120V
7.2KV

2

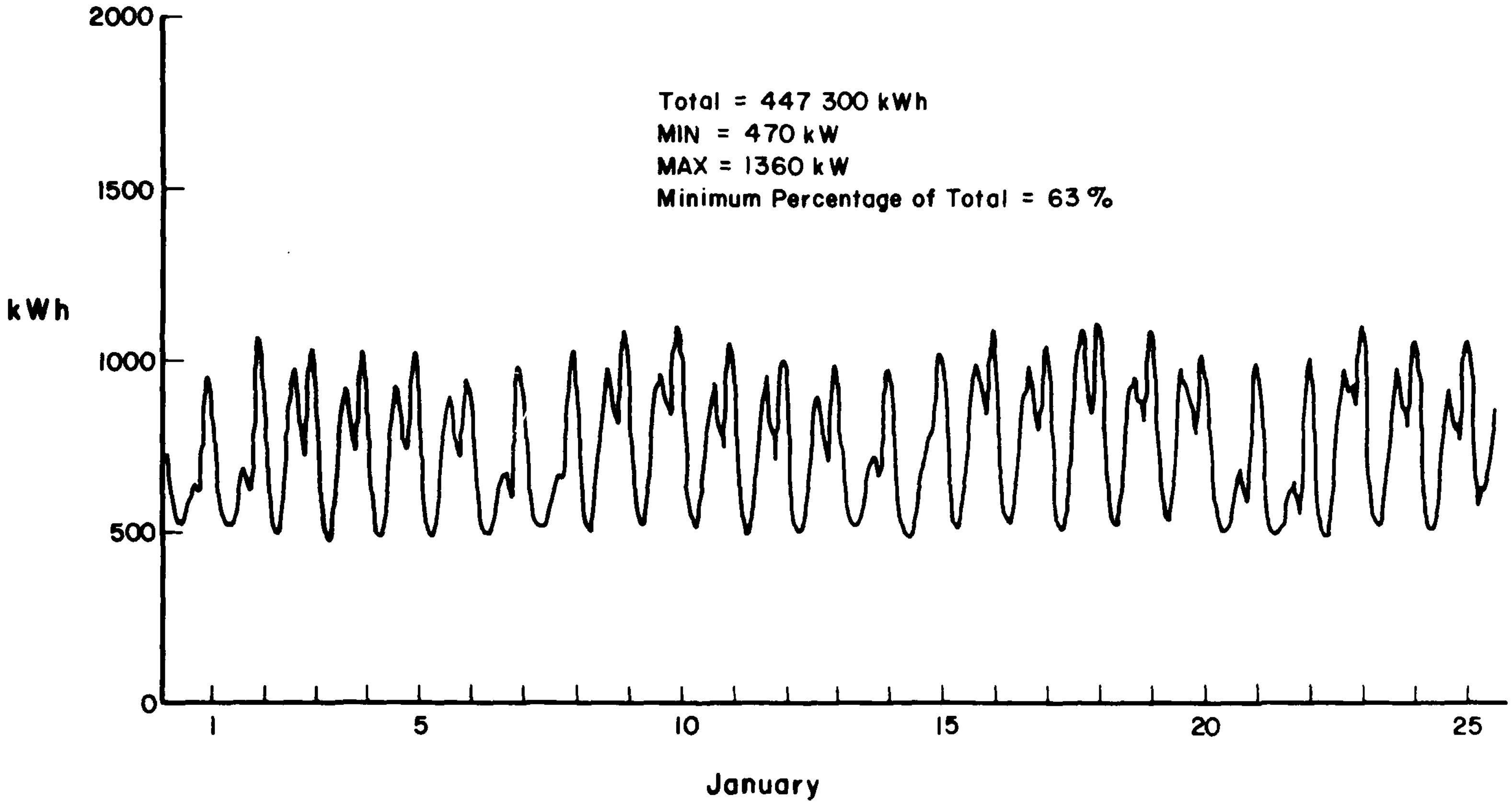


Figure 2. Monthly feeder profile -- winter (Fort Carson).

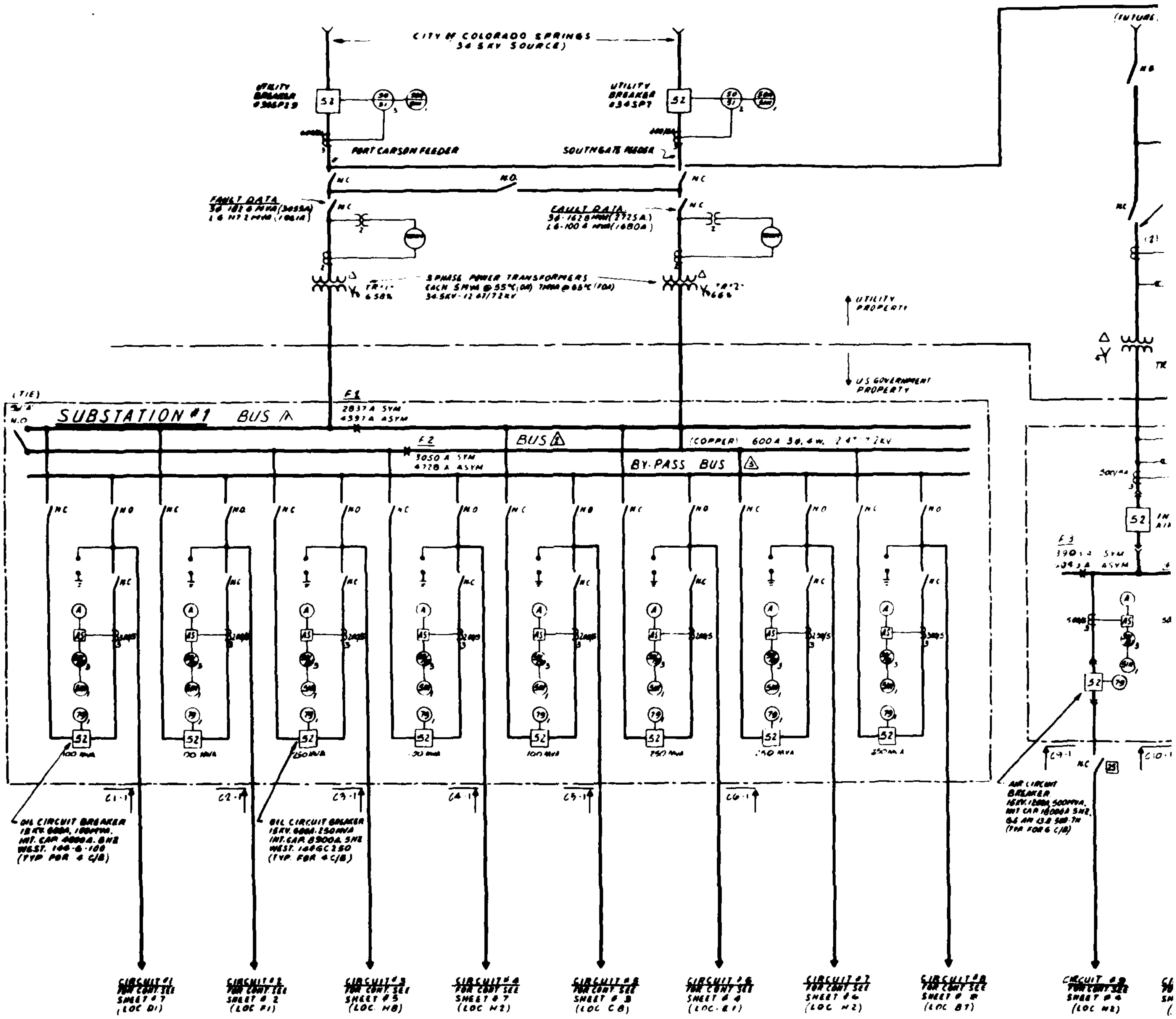
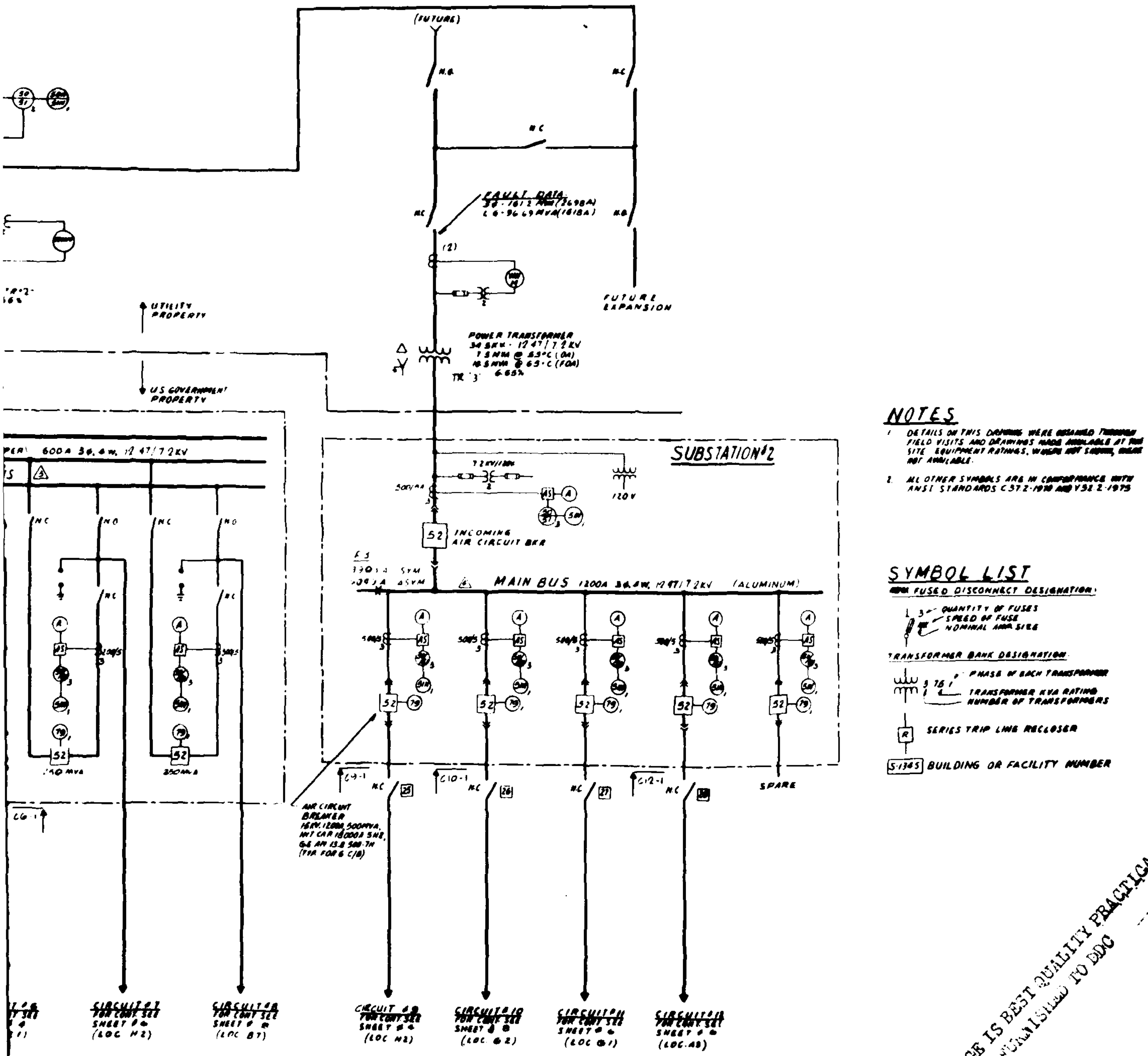


Figure 3. Buildings and systems serviced by Feeder 2 -- Fort Carson.


(FUTURE)
FAULT DATA
FUTURE EXPANSION
UTILITY PROPERTY
US GOVERNMENT PROPERTY
POWER TRANSFORMER
SUBSTATION #2
INCOMING AIR CIRCUIT BKR
MAIN BUS 1200A (ALUMINUM)
SPARE
AIR CIRCUIT BREAKER
NOTES
1 DETAILS ON THIS DRAWING WERE OBTAINED THROUGH FIELD VISITS AND DRAWINGS MADE AVAILABLE AT THE SITE. EQUIPMENT RATINGS, WHERE NOT SHOWN, WERE NOT AVAILABLE.
2. ALL OTHER SYMBOLS ARE IN CONFORMANCE WITH ANSI STANDARDS C37.2-1970 AND Y32.2-1975
SYMBOL LIST
FUSED DISCONNECT DESIGNATION:
QUANTITY OF FUSES
SPEED OF FUSE
NOMINAL AMP SIZE
TRANSFORMER BANK DESIGNATION:
PHASE OF EACH TRANSFORMER
TRANSFORMER KVA RATING
NUMBER OF TRANSFORMERS
SERIES TRIP LINE RECLOSER
S-1345 BUILDING OR FACILITY NUMBER

ort Carson.

2

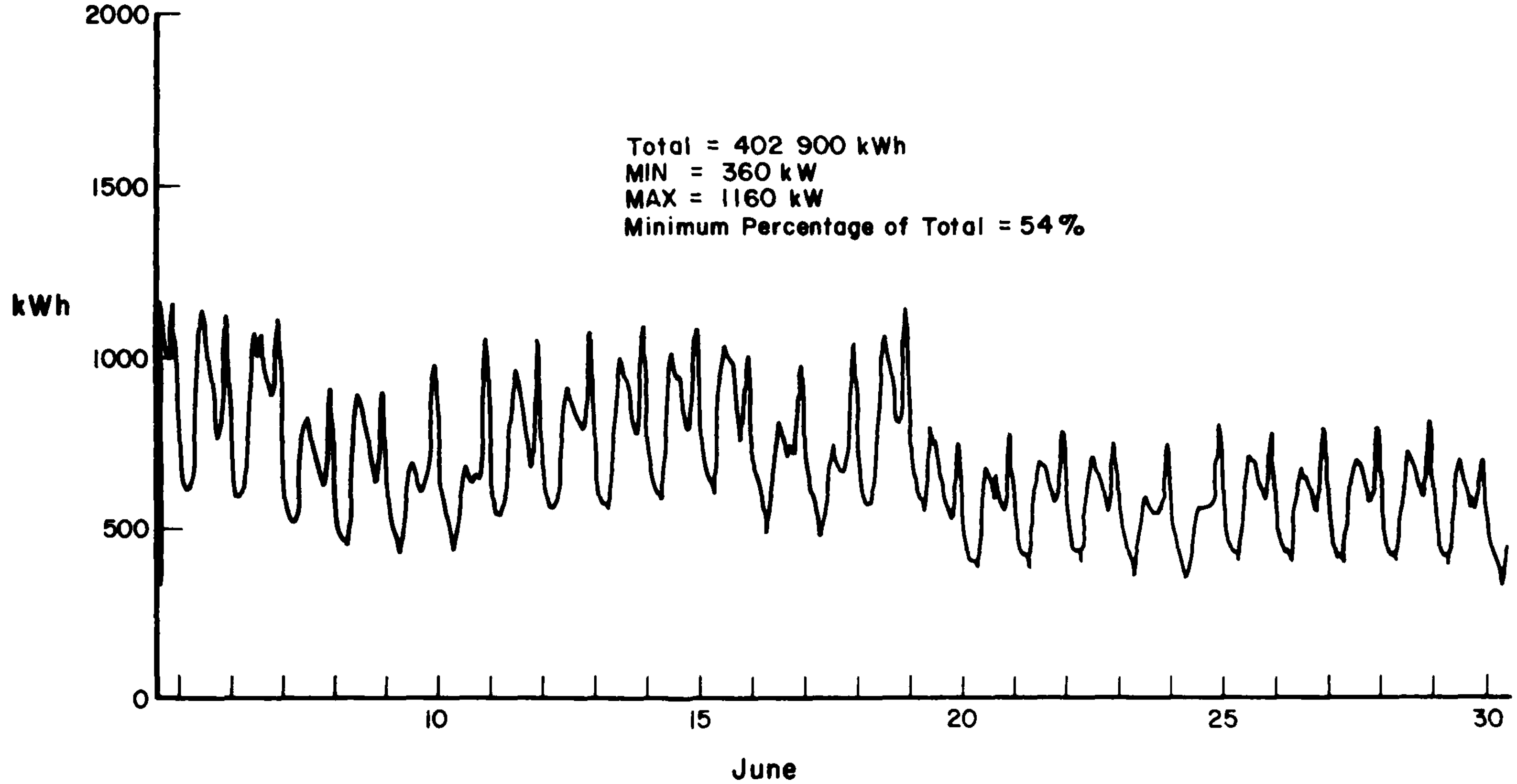


Figure 4. Monthly feeder profile -- summer (Fort Carson).

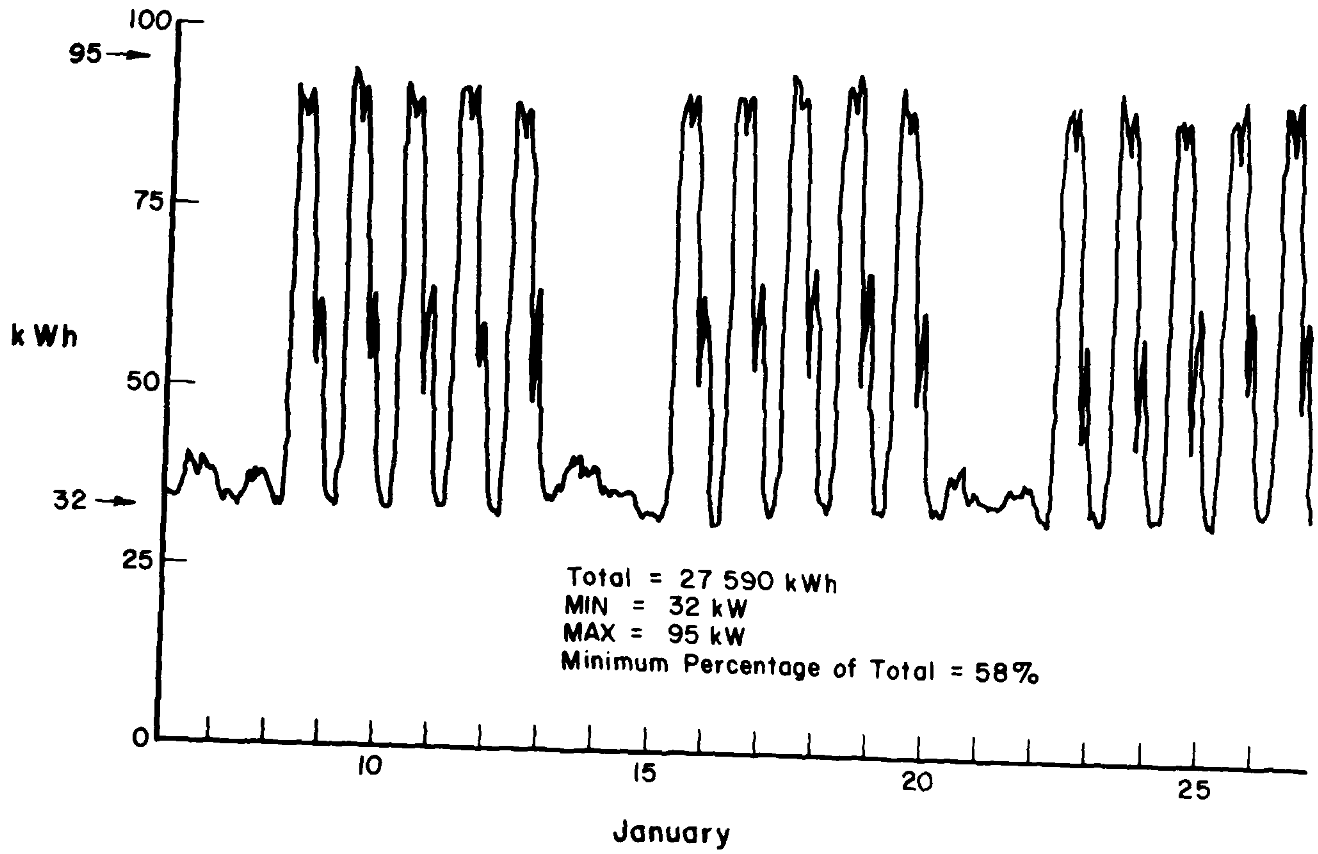


Figure 5. Monthly electrical profile -- winter (Building 1430).

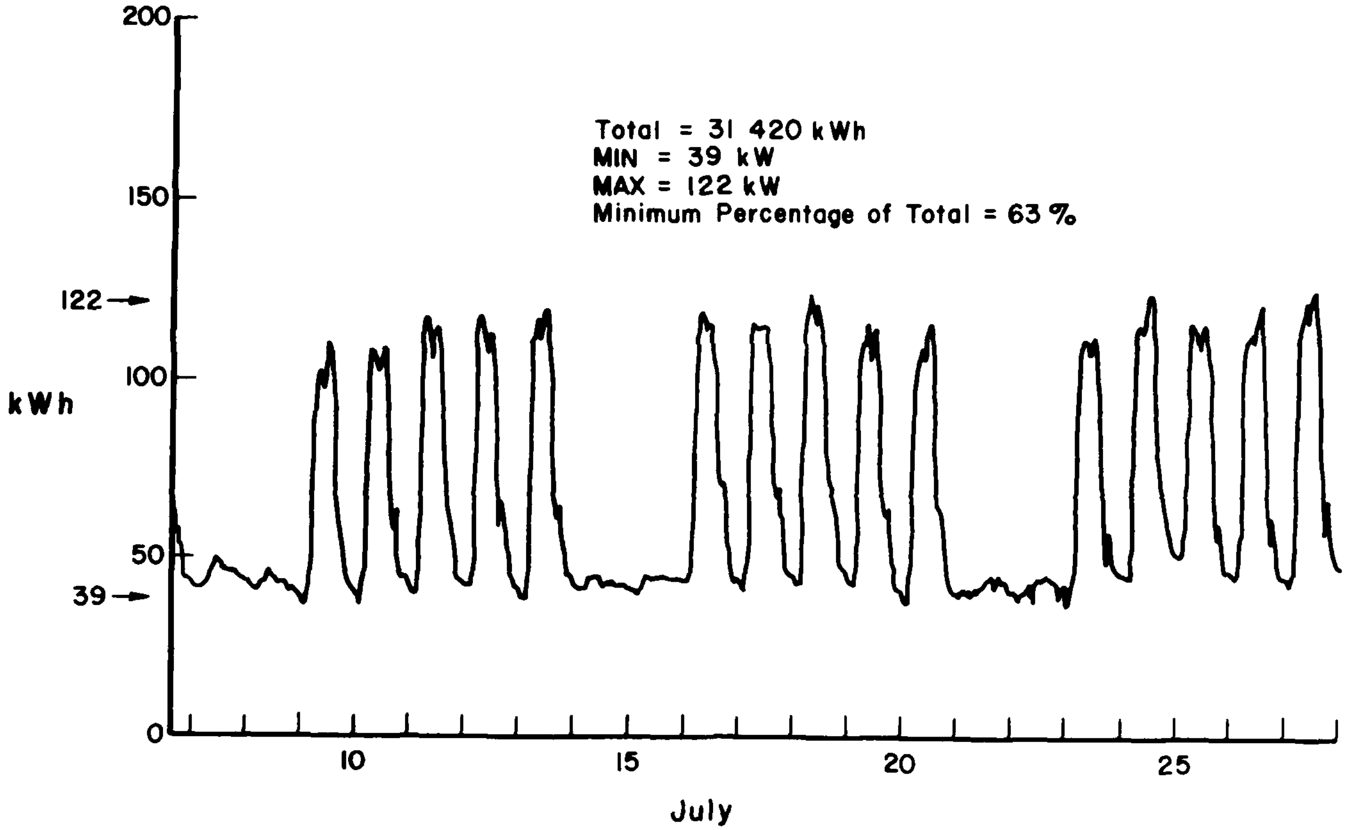


Figure 6. Monthly electrical profile -- summer (Building 1430).

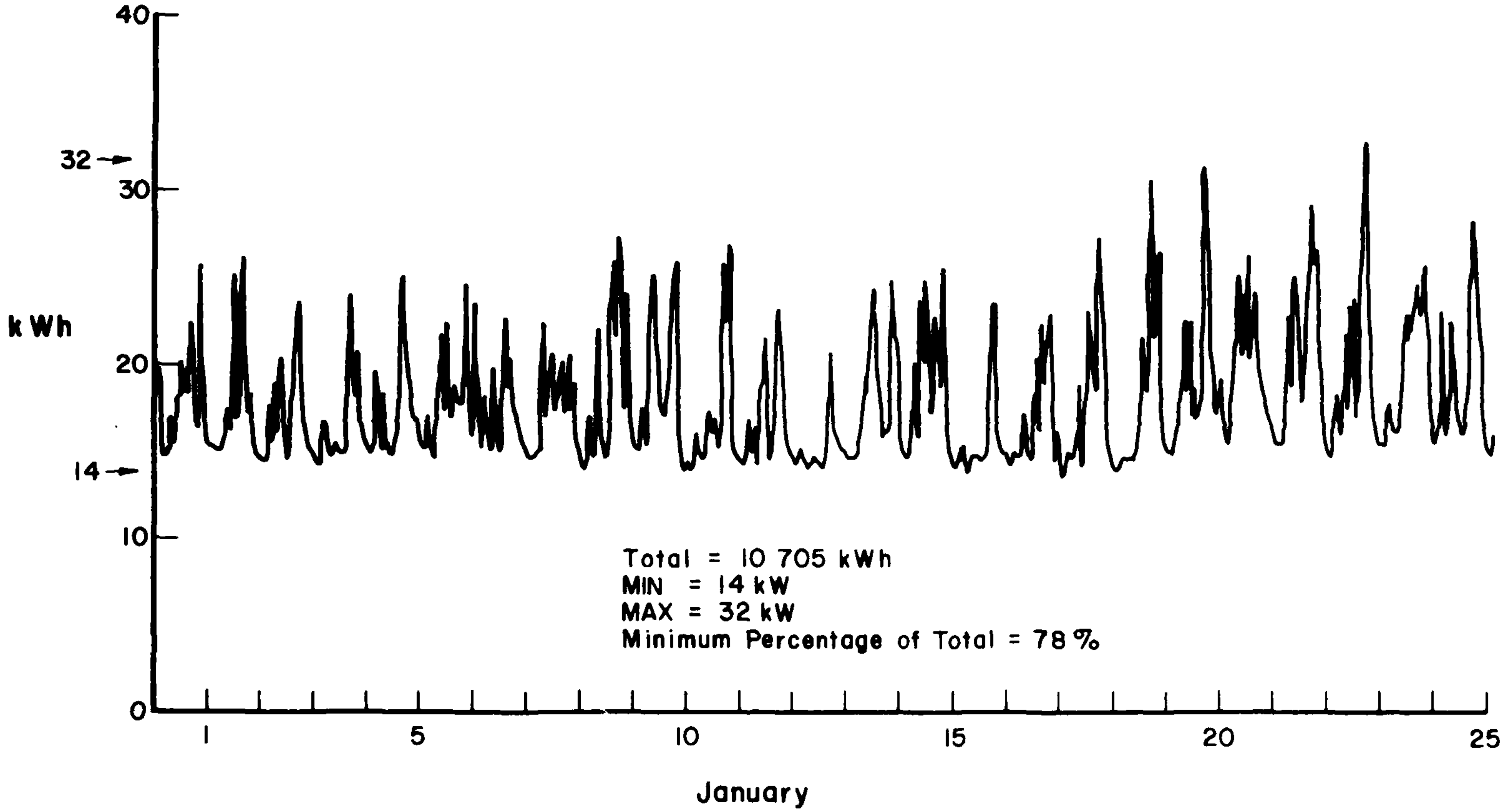


Figure 7. Monthly electrical profile -- winter (Building 1953).

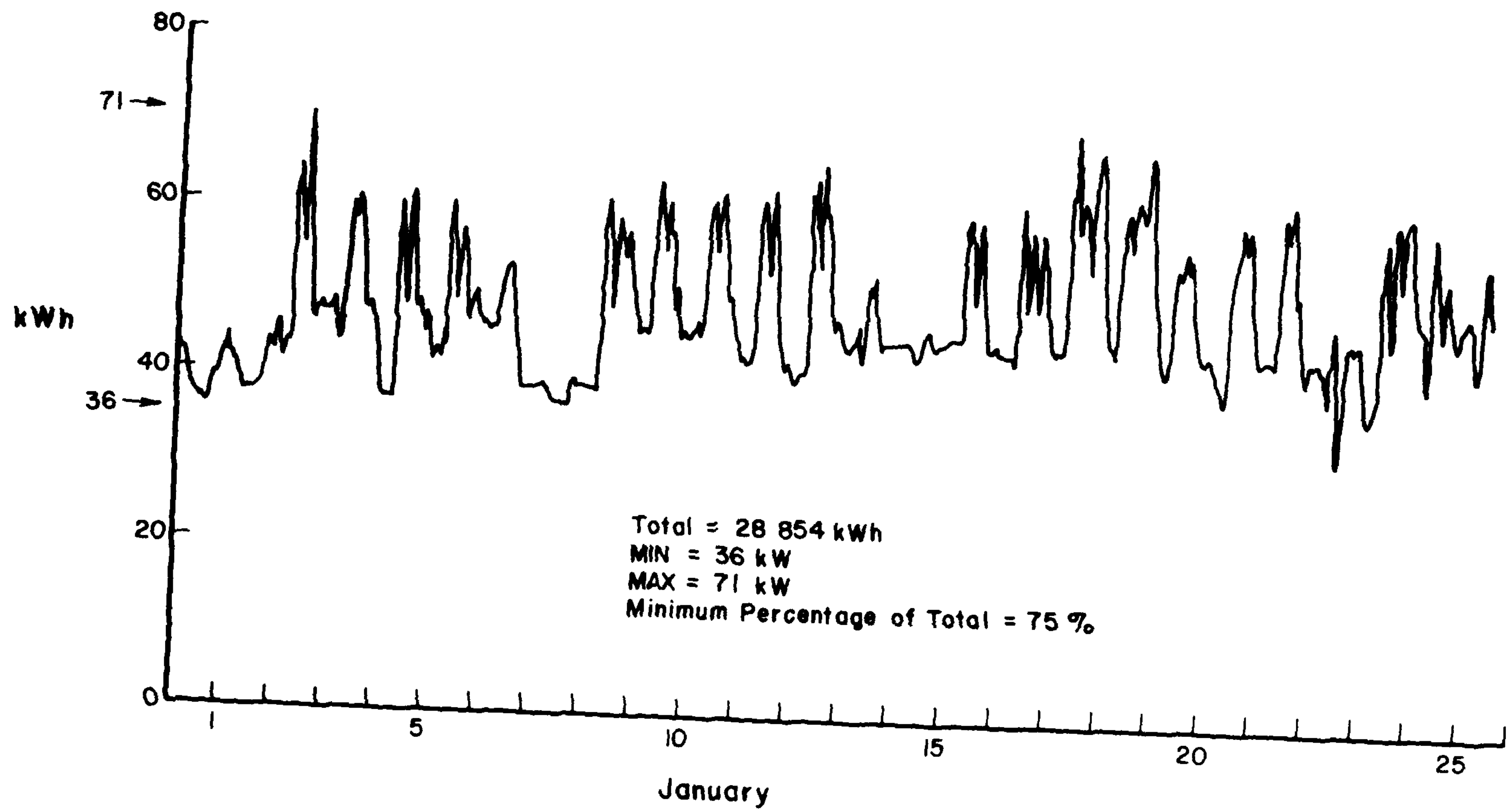


Figure 8. Monthly electrical profile -- winter (Building 2492).

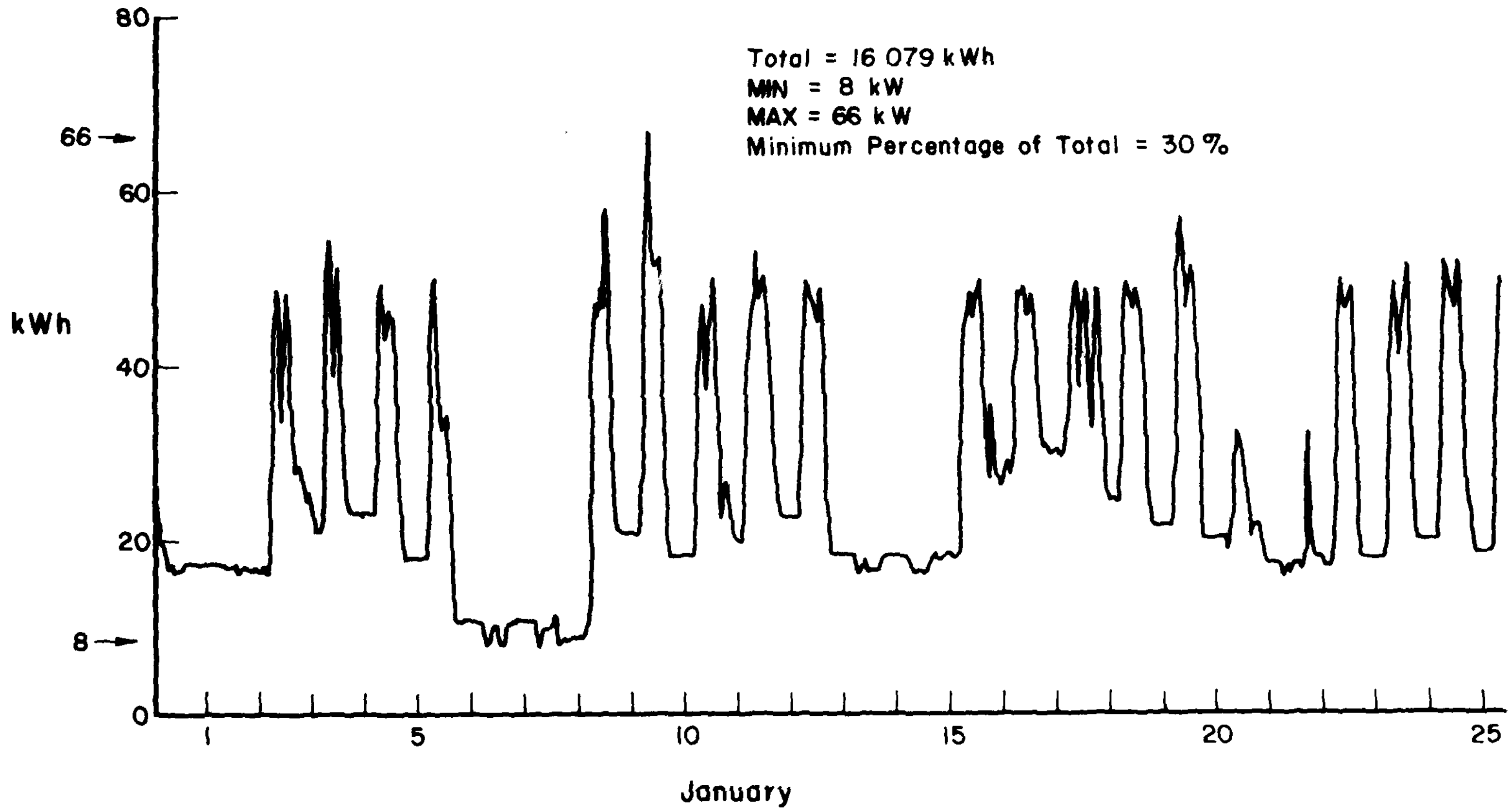


Figure 9. Monthly electrical profile -- winter (Building 2992).

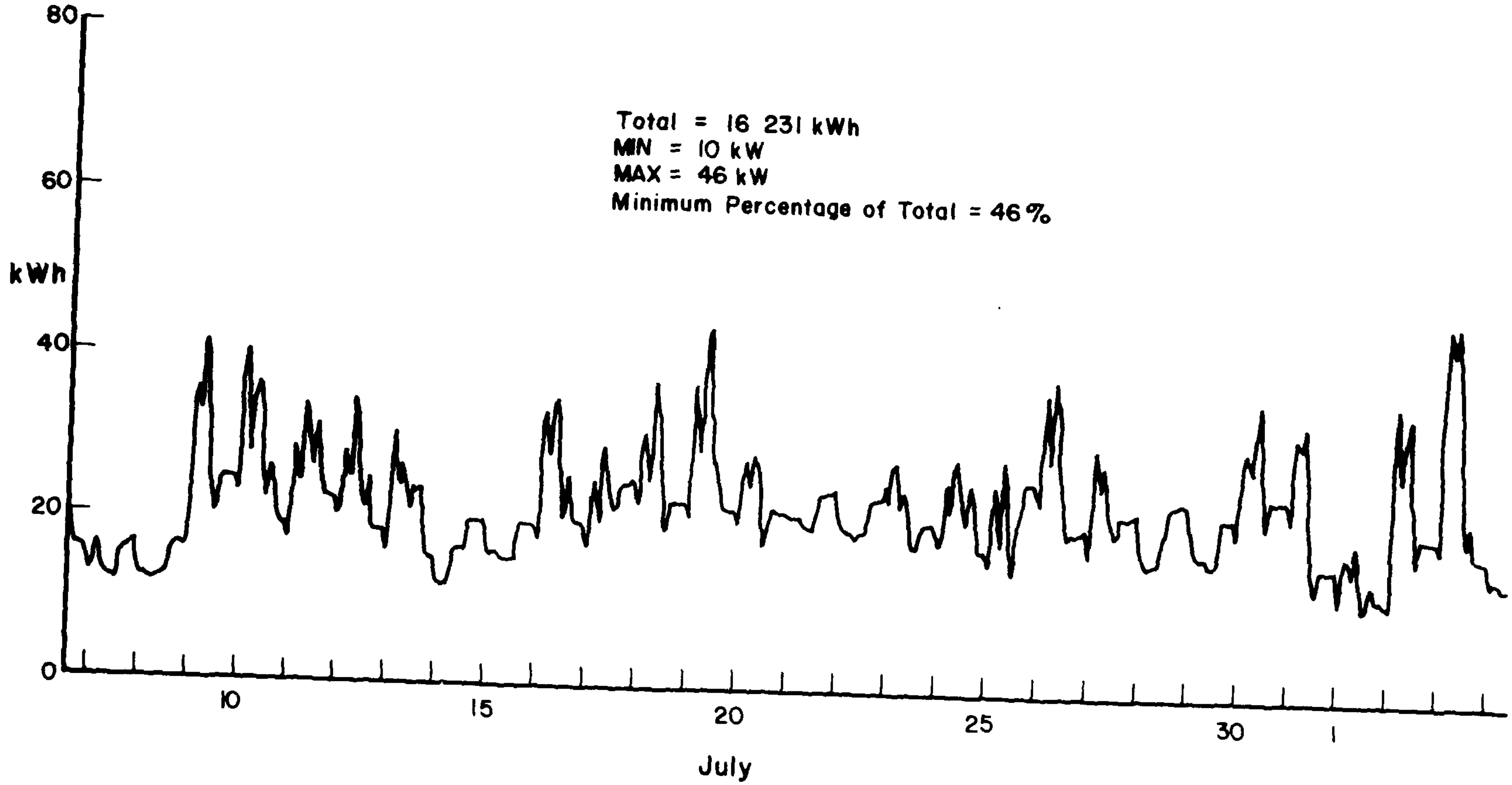


Figure 10. Monthly electrical profile -- summer (Building 2492).

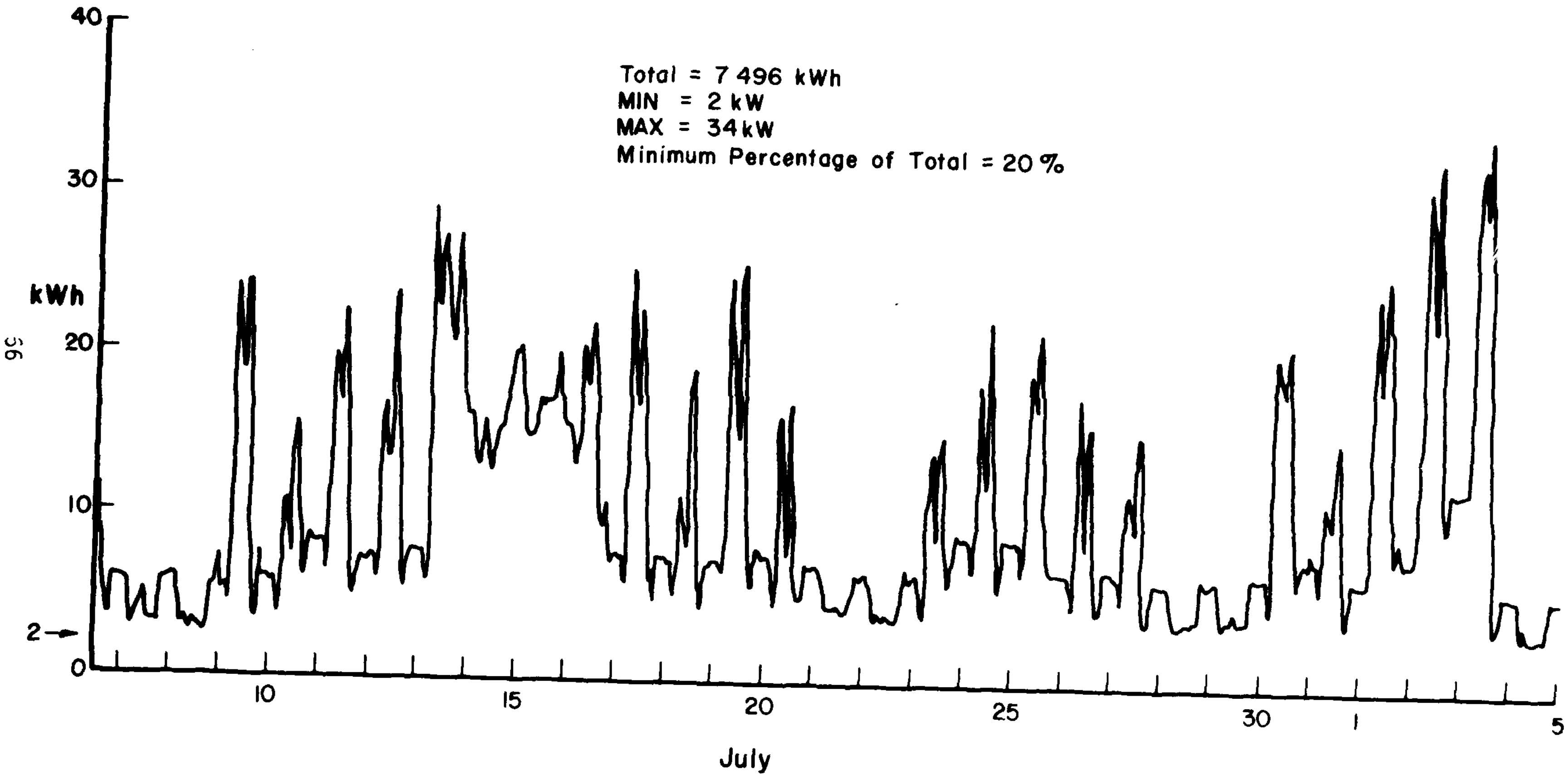


Figure 11. Monthly electrical profile -- summer (Building 2992).

APPENDIX:

BUILDING INSPECTION PROCEDURES

The procedures described in this appendix will help Facilities Engineers develop action plans for the immediate reduction of electrical energy use and to determine actions that can be programmed to reduce electrical energy consumption in the future. The procedures recommend the inspection of selected buildings and indicate actions that should be taken before, during, and after such inspections.

Background

Electrical consumption analyses of selected Army buildings indicate that some buildings consume up to 70 percent of their annual electrical energy during nonduty (unoccupied) hours. Therefore, major energy consumption reduction efforts should be directed toward reducing building base loads. The procedures described in this appendix are a way to identify and reduce building base loads and thereby reduce installation electrical consumption and demands. The attachment to this appendix is a suggested building inspection checklist.

Preinspection

Step 1: Develop a List of Buildings/Facilities To Be Inspected

During a recent study, it was found that some types of Army building categories use more electrical energy per square foot than others.[4] Table A1 summarizes the results of this study and lists the average portion of an installation inventory that each consumer group fills. In addition, the percent of total installation electrical consumption attributable to each consumer group is listed.

Table A1

Consumer Categories	Area of Post (%)	Electrical Consumption (%)
Community facilities	10	20
Administration/training	10	15
Maintenance/production	10	12
Bachelor housing	30	20
Family housing	30	20
Medical/dental	6	8
Storage	4	2

[4] B. Sliwinski, Fixed Facilities Energy Consumption Investigation -- Data Analysis, Interim Report E-143/ADA066513 (CERL, February 1979).

From this table, it is concluded that the buildings that offer the greatest potential for immediate reduction in electrical energy are community facilities, administrative/training facilities, and maintenance facilities.

Although other building types also consume considerable electrical energy, the inspection procedures described here were developed primarily for the listed building types. These building types also permit more immediate access to the building, inspections will cause less personnel impact than if they were conducted in living quarters, and they can usually be rapidly inspected.

Bachelor housing could also be inspected using these procedures; however, inspection would be limited to exterior and mechanical rooms, since full access to each room would be required to completely satisfy the requirement for an interior inspection.

The procedures should not be used for family housing. It is suggested a major public awareness program be developed and disseminated among family housing residents. This program should list actions family housing occupants can take to help reduce installation-wide electrical energy consumption.

Step 2: Assistance From Using Organization

A Building Monitor (a responsible individual assigned to the building by the using organization) should participate in the inspection and should be made responsible for reducing electrical energy consumption in his/her respective buildings. The Building Monitor should know what operations are required of building users and what the operational schedules and requirements of the building are.

The Building Monitor's major duties are: (1) to participate in the quick inspection, (2) to physically start or stop major equipment that has scheduled start and stop times, (3) insure building lights are off when the building is unoccupied, (4) monitor and reset thermostats for proper internal temperatures, and (5) report building or equipment deficiencies to the Facilities Engineer.

Step 3: Select or Contract for Inspectors

The inspector should have a practical knowledge of building drawings, interior electrical systems, and HVAC equipment operation; i.e., the individual should be able to trace an electrical branch circuit from the equipment back to a specific switching device and be able to readily identify HVAC equipment and air distribution system types. Where electrical panel boards may have to be opened to determine equipment switches, the inspectors should either be qualified electrical workers or be accompanied by a Facilities Engineer electrician. It is also suggested the inspector be accompanied by the HVAC maintenance mechanic/operator for the building.

Step 4: Develop a Schedule for the Inspection and Assign Inspectors to Specific Buildings

Inspections should be scheduled so that the inspectors can familiarize themselves with the building, building operation, and its HVAC system type. The inspector should contact the Building Monitor to coordinate a joint inspection of the building.

Step 5: Provide Inspectors With Information About the Building

The inspectors should be briefed on any special building requirements, i.e., HVAC system type, special equipment such as computers, special storage requiring controlled temperatures, or special building functions requiring temperature or humidity control (medical, dental, or battery storage). The inspector should have access to the building drawings so he/she can review the floor plan, locate the mechanical rooms, determine if roof-mounted equipment needs to be inspected, and familiarize himself/herself with HVAC system type and design operation.

Step 6: Tools and Instruments for the Inspection

The inspector should consider using the following tools and measuring equipment: clipboards, pad, pencils, screwdrivers, pliers, flashlight, mechanical room keys, thermostat keys, stick-on tape markers, ladder, a light meter, and a pocket insertion thermometer (to determine building temperatures).

Inspection

Exterior Inspections

The inspector should walk around the exterior of the building and note all exterior lights, open windows, doors blocked open and/or materials used to block doors open, operating exterior wall exhaust fans, operating window AC units, cooling towers, or air-cooled condensers. The inspector should also check for sealing or caulking around doors, windows, and other penetrations in the building wall such as pipes, communication wires, or electrical conduits. The outside air temperature and any obstructions (e.g., bird nests or debris) near outdoor air sensors or outside air intake ducts should be noted and recorded. If HVAC equipment, exhaust fans, or air intakes are on the roof, they should also be inspected. (Many of the suggested inspection items do not appear to be directly electrically related. However, energy conservation actions all tie together. For example, if the amount of hot or cold air required to meet a certain indoor temperature can be reduced by sealing and caulking, the electrical energy required to move this smaller quantity of air is also lowered.)

Interior Inspections

1. The inspector should measure the footcandle levels and identify the type of work being performed at three or four locations in the building and record this information on a rough sketch of the floor plan. The inspector should also check closets, mechanical rooms, and hallways for lighting levels and note if lights are left on when these areas are unoccupied. The type of lighting (incandescent, fluorescent, or other) should be recorded. If the building has been delamped, a spot check should be made to insure that ballasts have been disconnected. A spot check should also be made of lighting control -- for example, are all lights in large rooms switched by a single switch? The inspector should determine if additional switching is recommended.

2. The inspector should locate thermostats, record temperature settings, note if the AC or heating system is on, measure and record the room air temperature near the thermostat, and note if the thermostat has set-point temperature limiters or night setback control. If thermostat settings differ from 65°F (18.3°C) in the winter and 78°F (25.5°C) in the summer, the inspector should tell the Building Monitor to reset all thermostats to the appropriate level.

3. The inspector should check for furniture, drapes, carpet, or other foreign material blocking air diffusers or registers; check for open doors between conditioned and nonconditioned spaces; and note if any other major electrical energy-consuming equipment is present (e.g., communication equipment, television sets, vending machines, water coolers). The inspector should also determine whether or not freezer or refrigerating equipment have automatic defrost cycles.

Mechanical Room Inspections

1. The inspector should make a list of all major electrical energy-consuming equipment, noting all operating equipment. This list should identify any equipment that is or has been connected to timeclocks (inspections conducted during this study identified buildings where timeclocks were installed, but had been disconnected). The inspector should also determine which equipment can be shut off during unoccupied hours; e.g., water heaters can usually be shut off for 1 to 2 hours during occupied hours without negatively effecting personnel or equipment. (Major candidates for scheduling are air-handler motors, chillers, air compressors, exhaust fans, exterior lights, hot water heaters, and hot water circulating pumps.) The inspector should locate, identify, and mark switches for each piece of equipment that can be shut off or scheduled, then discuss a schedule for night and weekend shutoff with the Building Monitor.

2. The inspector should check for obvious equipment malfunctions, e.g., slipping or broken belts, dirty filters, excessive vibrations, rubbing or chattering noises, leaking pumps or pipes, wet pipes, wet pipe insulation, oil on the floor, rusted damper operators, or

excessively hot motors. The inspector should also check for blocked or improper damper positions by noting the air-flow condition and air temperature in the supply, return, and outside air ducts. (Inspections conducted during this study revealed totally closed/open and inoperative dampers in air handling systems.) The inspector should also check the setting of the outside air damper by physically observing the vane position and checking the outside air controller setting, if applicable. In most instances, the introduction of outside air should be minimized for energy conservation, consistent with health and safety. The inspector should check and note the supply and return water temperature for the hot and cold decks and observe and note the temperature setting of the hot water heater or converter so decisions can be made during the evaluation of the building in the next two phases.

Inspection Evaluation

Inspector and Building Monitor Requirements

After the inspection is completed, the inspector and Building Monitor should review the filled-out inspection forms to insure that all items have been covered. The inspector's documentation should be as complete as possible to avoid having to re-inspect the building. The inspector should suggest equipment scheduling or other electrical conservation measures to the Building Monitor. Comments on suggested actions should be made on the cover sheet of the inspection forms. These comments should include the inspector's opinion of what the building's major energy consumption problems are and any speculation he/she might make regarding suspected problems. Items that could not be inspected, or items which the inspector did not feel qualified to inspect, should also be noted. The completed inspection forms should be submitted to the Facilities Engineer.

Facilities Engineer

The Facilities Engineer should thoroughly review the inspection forms to determine actions that can be taken immediately, e.g., directing the Building Monitor to prepare a detailed schedule for turning off equipment at night and on weekends, setting back thermostats, or adjusting the building's operating temperatures. Based on the inspection results, the Facilities Engineer should initiate action to procure and install building conservation features such as timeclocks, temperature limiting/setback thermostats, or external monitoring lamps (to indicate operating equipment or radio control of equipment). Malfunctioning equipment should be repaired and improper operating parameters should be adjusted. For example, inspection form entries which show AC fans operating when outdoor temperatures are cool, hot deck temperatures that are high when only AC is required, or high air temperatures in supply ducts when chilled water temperatures are low are indications of specific problem areas.

The Facilities Engineer should also identify buildings where further electrical energy consumption reductions appear possible, but which have system complexities or building abnormalities that preclude a definitive electrical savings analysis and schedule such buildings for further study, including a thorough analysis of system and building operations.

INSPECTION REPORT

Building No. ______________

Building Use ______________

____

Date of Inspection ___________

Inspector ________________

Building Monitor ______________________________

Phone ________________ Office Symbol ______________

Alternate ____________________________________

Phone ______________________ Office Symbol ________________

Comments by Inspector and Building Monitor:

Facilities Engineer Review by ________________________________

Is building scheduled for energy monitoring and control? Yes No

Summary of Facilities Engineer Actions:

Attachment

EXTERIOR SURVEY

ITEM	YES	NO	COMMENTS
Lights on	--	--	
Open windows	--	--	
Doors blocked open	__	__	
Door blocks available	__	__	
Operating equipment	__	__	
Exhaust fans	__	__	
Window AC units	__	__	
Cooling towers	__	__	
Air cooled condensers	__	__	
Other____________	__	__	

	ACCEPT	MARGINAL	BAD
Sealing and caulking			
Doors	__	__	__
Windows	__	__	__
Other penetrations	__	__	__

Outside air temperature: ______________ ______________

Roof observations:

Equipment items (include voltage and full-load amperage)

Other problem areas:

Attachment

INTERIOR SURVEY

Lighting

Work type/areas	Lighting Level	Incandescent	Fluorescent
1	___	___	___
2	___	___	___
3	___	___	___
4	___	___	___
5 Closets	___	___	___
6 Hallways	___	___	___

Room Switch Control

___ Adequate ___ Inadequate

If delamped, are ballasts disconnected? Yes ___ No ___

If no, indicate location:

Thermostats

Area	Setpoint Temperature	Measured Temperature	Limiters Yes	Limiters No	Setback Yes	Setback No
___	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___

Are night setback thermostats recommended? Yes __ No __

Are temperature limiting thermostats recommended? Yes __ No __

AC system was: On __ Off __

Heating system was: On __ Off __

Attachment

Air flow blockages Yes __ No __
If yes, where:

Doors open between conditioned and nonconditioned spaces: Yes __ No __

List major electrical energy consuming equipment other than building HVAC within building (indicate voltage and full-load amperage):

Mechanical Equipment Room

Major Items of Equipment	Timeclock Installed		Timeclock Operating		Recommend for Clock Control	
	Yes	No	Yes	No	Yes	No
____________	__	__	__	__	__	__
____________	__	__	__	__	__	__
____________	__	__	__	__	__	__
____________	__	__	__	__	__	__
____________	__	__	__	__	__	__
____________	__	__	__	__	__	__

Attachment

Recommended Schedule (indicate start and stop time)

Equipment Item	Switch Location	Weekday Start	Weekday Stop	Weekend Start	Weekend Stop

Observation Item	Air Flowing Yes	Air Flowing No	Air Temperature
Supply duct			
Return duct			
Outside duct			

Outdoor air damper position ____________________

Hot deck supply temperature ________

Hot deck return temperature ________

Cold deck supply temperature ________

Cold deck return temperature ________

Domestic hot water temperature ________

Equipment discrepancies and problem areas:

Attachment

CERL DISTRIBUTION

Chief of Engineers
ATTN: Tech Monitor
ATTN: DAEN-RD
ATTN: DAEN-MP
ATTN: DAEN-ZC
ATTN: DAEN-CW
ATTN: DAEN-RM
ATTN: DAEN-CCP
ATTN: DAEN-ASI-L (2)

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Albuquerque
Baltimore
Buffalo
Charleston
Chicago
Detroit
Far East
Fort Worth
Galveston
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Jacksonville
Japan
Jidda
Kansas City
Little Rock
Los Angeles
Louisville
Memphis
Mobile
Nashville
New Orleans
New York
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Philadelphia
Pittsburgh
Portland
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Seattle
St. Louis
St. Paul
Tulsa
Vicksburg
Walla Walla
Wilmington

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Europe
Huntsville
Lower Mississippi Valley
Middle East
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North Pacific
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South Atlantic
South Pacific
Southwestern

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ATTN: Library

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FESA, ATTN: Library

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Engr. Studies Center, ATTN: Library

Inst. for Water Res., ATTN: Library

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DARCOM - Dir., Inst., & Svcs.
ATTN: Facilities Engineer
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Army Matls. and Mechanics Res. Ctr
Corpus Christi Army Depot
Harry Diamond Laboratories
Dugway Proving Ground
Jefferson Proving Ground
Fort Monmouth
Letterkenny Army Depot
Natick Research and Dev. Ctr.
New Cumberland Army Depot
Pueblo Army Depot
Red River Army Depot
Redstone Arsenal
Rock Island Arsenal
Savannah Army Depot
Sharpe Army Depot
Seneca Army Depot
Tobyhanna Army Depot
Tooele Army Depot
Watervliet Arsenal
Yuma Proving Ground
White Sands Missile Range

FORSCOM
FORSCOM Engineer, ATTN: AFEN-FE
ATTN: Facilities Engineers
Fort Buchanan
Fort Bragg
Fort Campbell
Fort Carson
Fort Devens
Fort Drum
Fort Hood
Fort Indiantown Gap
Fort Irwin
Fort Sam Houston
Fort Lewis
Fort McCoy
Fort McPherson
Fort George G. Meade
Fort Ord
Fort Polk
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Fort Riley
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Vancouver Bks.

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HQ, TRADOC, ATTN: ATEN-FE
ATTN: Facilities Engineer
Fort Belvoir
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Fort Leonard Wood

INSCOM - Ch, Instl. Div.
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Arlington Hall Station

WESTCOM
ATTN: Facilities Engineer
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  Energy Research and Development Foundation

Oak Ridge, TN 37830
  Department of Energy

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77 p. ; 27 cm. (Interim report ; E-163)

1. Electric power. 2. Energy consumption. 3. Military posts-energy consumption. I. Title. II. Series: U.S. Army Construction Engineering Research Laboratory. Interim report ; E-163.

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